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Washington County Project
A Final Report

Wisconsin Board of Soil and Water Conservation
Districts, Madison

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The primary objective of this project was to demonstrate the effectiveness of land control measures in improving water quality and to devise the necessary institutional arrangements for the preparation, acceptance, adoption, and implementation of a sediment control ordinance applicable to incorporated and unincorporated areas on a county-wide basis.

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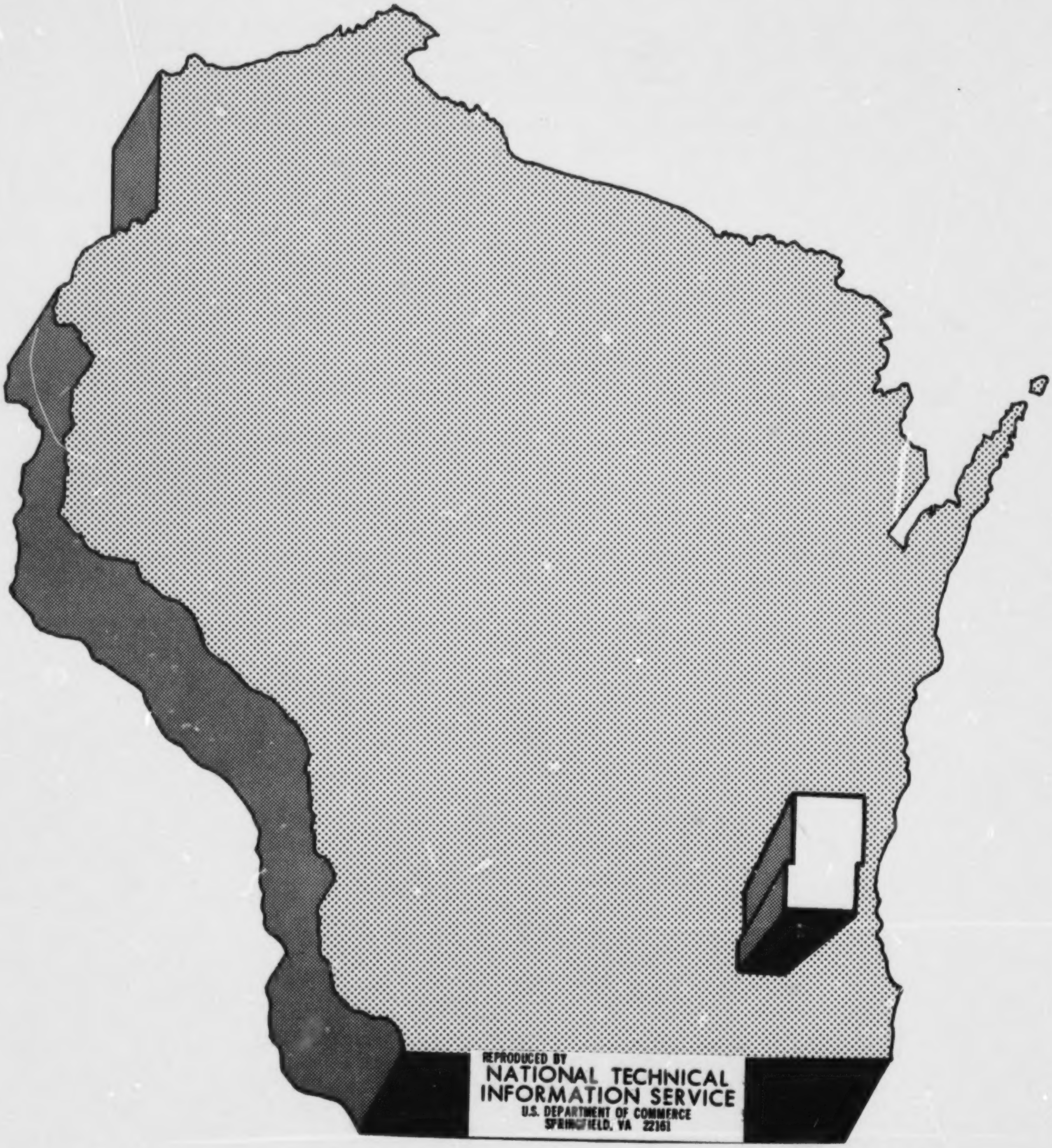

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Wisconsin Board of Soil and Water Conservation Districts
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U.S. Soil Conservation Service
Wisconsin Department of Natural Resources
Wisconsin Geological and Natural History Survey
Washington County Soil and Water Conservation District
Southeastern Wisconsin Regional Planning Commission
National Association of Conservation Districts
The University of Wisconsin System
Village Board of Germantown
Washington County Board

The Washington County Project
Final Report

Development and Implementation of a Sediment Control Ordinance or Other Regulatory Mechanism: Institutional Arrangements necessary for Implementation of Control Methodology on Urban and Rural Lands.

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INTRODUCTION

The Washington County Project was funded by the U.S. Environmental Protection Agency under Section 108 of the 1972 amendments to the Federal Water Pollution Control Act (P.L. 92-500). The Wisconsin Board of Soil and Water Conservation Districts was the prime contractor for the project, which also involved the University of Wisconsin-Extension, the Water Resources Center of the University of Wisconsin System, the Wisconsin Department of Natural Resources, the Southeastern Wisconsin Regional Planning Commission, the U.S. Geological Survey, and the Washington County Soil and Water Conservation District.

The overall project goal was to determine which institutional mechanisms and land management changes would be most effective in reducing erosion and sedimentation in Washington County, Wisconsin. A reduction in sediment loadings is needed to reach the 1983 water quality goal of fishable-swimmable water established by P.L. 92-500.

Washington County was selected for the project because it has a strong rural tradition, but is under intense urbanizing pressure from the nearby Milwaukee metropolitan area. Thus, the county serves as an excellent location to develop rural and urban sediment control programs.

Washington County Environmental Setting

Washington County is located in southeastern Wisconsin, northwest of the Milwaukee metropolitan areas. In 1975 the county population was 76,577, half of which reside in 13 unincorporated towns, the remainder in 2 cities and 5 villages. Farms account for 60% of the land area in Washington County but only 6% of the county's population live on farms.

Land use patterns in Washington County are representative of many areas in the Great Lakes Basin which are adjacent to rapidly expanding metropolitan areas. The northern tier of the county is relatively stable and consists mainly of dairy farms averaging about 40 milk cows/farm. Patchwork residential development is more common in the southern part of the county and surrounds the major urban centers of West Bend and Hartford. Farming in these areas more often is a transitional activity; dairy farms have frequently been converted into cash-crop operations.

Open space and recreational activities center around the county's many lakes, streams, wetlands and forests. The Kettle Moraine crosses south to north through the center of the county. Many beautiful farm and forest scenes result from the unique, varied Kettle Moraine topography.

Information was gathered on water pollutants, erosion and sedimentation problems and on public perceptions of these conditions in Washington County. This information was needed to help identify, at least preliminarily, the nature of the problems and to provide an information base for use in evaluating the impacts of alternative sediment control programs.

Water quality conditions and problems in the county vary widely. Some streams and lakes have very high quality water and support diverse, productive fisheries, e.g., Allentown Creek, Oconomowoc River, Pike Lake. Water quality is degraded in other lakes and streams, e.g., Hartford Millpond, Cedar Creek, Monomonee River. Pollutants are generated from point and nonpoint sources. The most common nonpoint source problems in streams and lakes result from excessive nutrient loadings. Suspended sediment levels also are frequently higher than desirable. It has been estimated that agricultural nonpoint sources contribute about 65% of the sediment and phosphorus to Washington County waterways; construction sites account for about 20%; and urban point and nonpoint sources account for the remainder. Agricultural contributions of phosphorus are attributed primarily to livestock, while sediment arises mainly from croplands. It has also been determined that most of the sediment is contributed by only a small portion of the county's cropland (1). In Washington County most of the cropland erosion was found to be from lands with slopes > 6% either plowed up and down hill or planted to continuous corn. It is concluded that substantial water quality improvements are possible if control efforts could be focused on areas most in need of treatment, i.e., the "so-called" hydrologically active areas.

Attitudes Toward Water Quality

Washington County residents in general do not see pollution of their lakes and streams as a major concern. Only about 30% of the rural and urban residents surveyed felt water pollution in the county is a "very serious" or "somewhat serious" problem (2). Participants in public meetings were much more concerned about preserving prime farmland. Overuse of lakes was seen as the main water resource management issue. Many residents of rural areas felt that city residents using the waters for boating and swimming are the primary beneficiaries of the rural water pollution control efforts.

Potential benefits for recreationists from improving water quality were found to be high. The survey of about 500 day-users at eight lakes in southeastern Wisconsin indicated:

- People are generally aware of water quality differences between lakes.
- Water quality and aesthetic considerations are the most important factors influencing the selections of a lake for recreation.

- At Pike Lake, the cleanest lake in the survey area and the only lake entirely within Washington County, 28% of the respondents perceived a pollution problem. Moreover, Pike Lake users expressed a willingness to pay nearly $1.00/visit to improve lake water quality (3).

The surveys also indicated a general lack of awareness of the connection between water quality problems and erosion or other nonpoint sources of pollution. Less than 20% of the county residents and < 10% of the lake users felt agriculture was the major source of the county's pollution problems (2). County residents living in urban areas tended to place greater blame on agriculture than those living in rural areas. While about 70% of the farmers surveyed considered field runoff to be the major agricultural problem, > 95% felt that soil losses from their land were either lower than or the same as the losses from other farms. Only 2% thought that soil loss from their land was higher than average. From a study of other survey results, however, it was concluded that about 15 to 20% of the land could be considered to have erosion rates greater than the county average (1).

These survey results indicate a general lack of knowledge of the relationship between sediment pollution and water quality conditions, and highlight the necessity for a strong educational and informational effort if sediment control programs are to be successful.

The Project in National Context

The Washington County Project was an ambitious one given the objectives of demonstration as well as related research undertakings. In considering the accomplishments as well as the shortcomings of the project, it is necessary to be aware of the context in which the project was carried forward. The project in temporal terms was carried out concurrently with the area-wide quality planning process under Section 208 of P.L. 92-500. Therefore, proposals for project demonstration necessarily were put forward for consideration before regional plan consensus was firm and before the State of Wisconsin and the federal establishment had settled on their first phase action program for nonpoint pollution abatement.

The most significant factors affecting the project are summarized below:

1. The national clean water policy as defined in P.L. 92-500 (1972) dealt with all facets of water pollution abatement. The point source program was built on substantial operating experience, but nonpoint source abatement programs were "uncharted seas" for all levels of government and the body politic. Potential regulation of nonpoint sources under federal mandate was required "to the extent feasible". However, such a dynamic program was subject to shifts in emphasis during the course of its development.

2. Whereas point source abatement programs dealt with pollution from specific sites, nonpoint programs by definition involved substantial areas of urban, urbanizing and rural lands which generally have not been subject to federal and state intervention; rather these lands have been typically used and managed subject only to local governmental controls.

3. Historically, the federal and state government programs affecting privately-held agricultural and forest lands have involved education, technical assistance and cost-sharing as inducements to remedial action. The USDA's Soil Conservation Service and Agricultural Stabilization and Conservation Service operated cooperatively with state and local instrumentalities. The nonpoint program, however, potentially introduces an element of governmental control of private lands.

4. The nonpoint program represents a complex maze of intergovernmental relationships within the federal and state systems. All levels of American government are involved. Both water and land related functional agencies are essential participants in the program. But at both national and state levels there are distinct differences in organization and functional style between the water quality agencies (USEPA and WDNR) and the agriculturally related agencies (USDA and Wisconsin's Soil and Water Conservation District structure).

5. Institutional responsibility within Wisconsin state government for a nonpoint program is lodged with two separate agencies. Wisconsin's water quality agency, the Department of Natural Resources, functions under broad state mandate, but does not exercise direct control over private land usage, and is not represented administratively at the county level. The State Board of Soil and Water Conservation Districts is a separate state entity performing only missions of support to the Soil and Water Conservation Districts organized on a county by county basis.

6. The project was necessarily limited to existing state legal authority as the basis for proposed governmental actions. That which could be considered and proposed at the county level had to fit within powers already granted by state statute.

7. The demonstration elements of the project were a social experiment and as such were subject to the institutional constraints and the socio-political variables operable at the several levels of government. Changes in state and national programs served to complicate what was recognized at the outset as less than a controllable experiment

8. The institutional demonstration efforts were carried forward in a "real political world" context as distinguished from physical and biological demonstrations, subject only to the vagaries of climate. The "real political world" was grass roots, local government with the policy-administrative decision-makers accountable to their

voting constituents. The Washington County authorities were generally responsive to project recommendations, but the substance and timing of their actions were properly conditioned by their judgment of their political responsibilities.

We believe a major contribution of the project, albeit difficult to document in a formal report, was to serve as a focal forum for discussion among the several agencies as each proceeded concurrently with their respective responsibilities. County and state and federal agency positions influenced the project's work. Likewise, we believe the project team was influential to some degree with these agencies.

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PART I

LEGAL AND INSTITUTIONAL UNIT
FINAL REPORT

by

JIM ARTS

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SUMMARY OF GOALS AND ACCOMPLISHMENTS

The overall goal of the institutional unit of the Washington County Project was to design and implement programs to control sediment pollution in Washington County (1). The project was designed to determine whether local governments--given technical assistance and financial support--would be willing to enact and implement sediment control programs, and to determine whether these programs would be effective in reducing sediment loadings. The information obtained from the project research will aid policymakers in evaluating future sediment control strategies. Specific goals included:

1. Evaluation of legal, economic, political, and administrative effects of alternative regulatory programs for sediment control.
2. Review of the alternative programs with local officials.
3. Assistance to local officials in their effort to enact and administer effective and politically acceptable sediment control programs.
4. Analysis of the impact of related state and federal programs.

To ensure that the sediment control programs were politically acceptable and could be administered efficiently and equitably, it was deemed essential to have the continued input of local officials. Valuable exchanges of information and ideas came from the Washington County Soil and Water Conservation District (SWCD) supervisors, and representatives of the project attended most of the monthly SWCD meetings. Local project advisors met quarterly to review and discuss alternative programs. Members of the Washington County Board of Supervisors and county level representatives of University of Wisconsin-Extension, the U.S. Soil Conservation Service, and the U.S. Agricultural Stabilization and Conservation Service also provided valuable information.

Research focused on agencies and sediment problems in Washington County, but in some cases, programs in other counties and states were studied to give a broader perspective to the Washington County research. All implementation programs occurred in Washington County.

Project researchers and advisors included representatives from a wide variety of agencies and academic disciplines. Day-to-day operations of the program were conducted by a group of University of Wisconsin-Madison personnel from urban and regional planning, soil science, water resources management, law, economics, and political science. Biweekly meetings brought together these members with the project director and representatives of several state and federal agencies, including the Wisconsin Board of Soil and Water Conservation Districts, the Wisconsin Department of Natural Resources, the U.S. Soil Conservation Service, and the Southeastern Wisconsin Regional Planning Commission.

Specific and identifiable accomplishments of the institutional unit include:

1. Enactment of construction site erosion control ordinances for all of the unincorporated areas of Washington County and for some of the incorporated cities and villages.
2. Completion of an analysis of the mission and performance of related federal, state, and local programs. This information is found summarily in this report and in more detail in the papers listed in the bibliography.
3. Completion of studies in governmental decision-making, including inter-governmental and interest group dimensions, comparisons among states, and decision processes in Washington County compared to other Wisconsin counties.
4. Extensive land use and water quality information has been collected, analyzed, and furnished to local decision-makers for their use in program planning.
5. Local programs have been expanded and focused in a coordinated fashion upon critical sediment problems.
6. An ordinance to regulate sediment from farmlands has been drafted, and projected economic and water quality impacts discussed in detail with local officials and other residents.
7. The Washington County Board of Supervisors has, by resolution, approved a policy statement endorsing the 3 ton/acre soil loss limit.

THE INSTITUTIONAL SETTING

An initial objective of the project was to determine the set of agencies involved in erosion and sediment control programs and to evaluate the effectiveness of these programs. The following analysis summarizes the essential features of key agencies in Washington County but it is generally applicable to other Wisconsin counties.

Local Level Agencies

County Board of Supervisors

As the governing body for the county, the 30-member Washington County Board of Supervisors form the heart of local government for the unincorporated areas of the county. The county board has a direct or indirect effect upon most local programs.

As a general unit of local government, the county has been delegated --by the state legislature--substantial administrative and policy-making authority over a wide range of local concerns. With regard to sediment control, the county presently:

1. Enacts and administers county zoning, subdivision plat review, and building permit ordinances;
2. Administers state shoreland and floodplain zoning and farmland preservation programs;
3. Provides locally-derived revenue for Soil and Water Conservation District (SWCD) operations;
4. Promotes coordination among county level committees (agriculture and extension education, zoning, county planning commission, and SWCD);
5. May fund local cost-sharing program.

Whatever particular focal point for the local sediment control program is selected, the county board and its committees will play a vital role.

Analysis of the Washington County Board of Supervisors shows that the board is composed of members who are older than the median age of the population (half are retired) and who, as a general rule, have had substantial experience at other levels of government, particularly the town board (2). Although town board members no longer serve *ex officio* as members of the county board, some town board members are still elected—in separate elections--to the county board as well as to the town board. In Washington County four of the 13 town board chairpersons serve on the county board.

The studies show that little competition exists for county board positions. In fact, most board members feel that their constituents are generally unaware of the board's functions; however, most members believe that their perceptions of the needs and interests of the districts are similar to those of their constituents.

The board exhibits a consensual decision-making style; that is, on virtually all issues, all, or very nearly all, of the members reach agreement. Rarely is a serious difference of opinion expressed once a question reaches final vote.

This tendency of the Washington County Board to reach a consensus is caused by three factors:

1. There is extensive use of the committee system with consequent increase in individual expertise in certain areas and mutual deference to this expertise. Thus, decisions made in committee are seldom challenged by the whole board.

2. A high level of homogeneity and congeniality exists among the members; they share many common interests, and like and respect each other.

3. Little citizen pressure is placed on board members. Generally, the members are entrusted to represent the best interests of the community and, respecting this trust, they vote as they believe the average well-informed citizen would vote.

These observations suggest that the immediate and direct involvement of the appropriate committee is the best way to secure meaningful consideration of desired local legislation.

In Washington County, two committees of the county board deal most directly with the sediment control issues. These are the Park and Planning Commission and the Agriculture, Extension Education, and Conservation Committee.

The Park and Planning Commission has seven members, four of whom are not county board members. The commission is responsible, among other things, for duties relating to county zoning ordinances and county subdivision (or land division) ordinances. These programs are administered by the Land Use and Park Department, which is responsible to the Park and Planning Commission.

The Park and Planning Commission (or its equivalent in other counties) may play an important role in sediment control in at least two areas:

1. As the agency responsible for the administration of subdivision ordinances, it may recommend to the county board the adoption of erosion control amendments to those ordinances and, if such amendments are adopted, to administer them.

2. It may propose revisions to county zoning ordinances, including shoreland zoning ordinances.

The commission will play a central role in determining which of these programs will be adopted and will guide the administration of the programs once adopted.

The five-member Agriculture and Extension Education Committee directs the work programs of the county extension agents who, in addition to other duties, may provide information on sediment control programs to farmers, other landowners, and the general public. In addition, the members of this committee serve as the supervisors of the Soil and Water Conservation District. This dual responsibility provides the potential for close coordination of the programs of the SWCD and of the extension agents.

The Soil and Water Conservation District

The Soil and Water Conservation District (SWCD or district) is responsible for a wide range of resource conservation programs. Boundaries of the district are coterminous with county boundaries. Operating under authority of Chapter 92 of the Wisconsin Statutes, the district is governed by the five county board supervisors who comprise the Agricultural and Extension Education Committee. The county board has the authority to appoint one or two additional members (not members of the county board) to serve as district supervisors. Board powers related to sediment control programs have been delegated to the district. It is directed to develop long-range "comprehensive plans for the conservation of soil, water and related resources within the district" which should also specify how the plans will be implemented [Wis. Stat. §92.08(4)]. An annual plan is to be developed "which shall describe the action programs, services, facilities, materials, working arrangements and estimated funds needed to carry out the parts of the long-range program that are of the highest priorities" [Wis. Stat. §92.08(4)(b)].

The district is also given the authority to administer state or federal programs for soil conservation, flood prevention, water management, erosion control and prevention, and to participate in any other programs related to conservation of natural resources within its boundaries [Wis. Stat. §92.08(7)].

The SWCD has close working relationships with the Soil Conservation Service (SCS) and the University of Wisconsin-Extension; these relationships are defined in memoranda of understanding between the SWCD and the agencies. In addition, the state Board of Soil and Water Conservation Districts (BSWCD) provides information, assistance, and some state-appropriated financial support. A close association also exists between the county board, town boards (in Washington County, four of the five SWCD supervisors are chairmen of their respective town boards), the Agricultural Stabilization and Conservation Service (ASCS), the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and the Wisconsin Department of Natural Resources (DNR). Representatives of these and other agencies participate in the drafting of the district's annual work plan at its annual planning meeting. The SCS, Extension, and BSWCD representatives usually participate in the SWCD monthly meetings (3).

The SWCD has authority to enter into cooperative agreements with other governmental bodies and with private landowners to promote erosion control and flood prevention programs. The SWCD provides technical assistance--usually with the help of the SCS-- to design and install needed conservation practices.

Wisconsin Statutes (§92.09) provide that the SWCD may propose and the county board may enact land use regulations for erosion and sediment control in incorporated areas. People living in the area to be affected by the regulations must approve them in a referendum before the regulations are effective. In the entire state only Vernon County has enacted an ordinance to control soil loss under this section, and it is too early to say whether this ordinance has been effective in reducing erosion.

The combination of the district's legal authority to administer sediment control programs and its extensive interagency relationships suggest that the SWCD is an appropriate focus for sediment control programs. However, this conclusion is not reached without acknowledging that the districts have limitations as well as strengths.

One shortcoming is that the districts have, as a general rule, not effectively exercised all of the authority they have. Neither the SWCD long-range nor annual planning processes have yet been effectively utilized to establish the authority of the district over program policy within its jurisdiction. Neither sufficiently acknowledges past program deficiencies, quantifies treatment needs, prioritizes a sequence of objectives, nor specifies where needs are greatest in the district. This has resulted in implementation efforts which are frequently inconsistent with district policy. The district's weakness in this area can be attributed--at least in part--to its inadequate professional staff.

In many counties, including Washington County, the district has not been able to convince the county board that it should provide the district with funds to hire professional staff. In some cases, there is a reluctance to pay the salary required to employ such a person or persons;

in other cases, there is a fear that the SWCD staff, in assuming their legitimate duties, may conflict with the SCS District Conservationist who has been doing many of the administrative and policy-making duties in the past. In Wisconsin 50% of the counties have a total SWCD budget of < $25,000, some of which is appropriated by the state (3). Without adequate staff, the district supervisors are unable to manage an expanded sediment control program. It should be noted that SWCD supervisors serve on several other committees and have many other governmental duties in addition to being employed and having other community responsibilities. It is not possible for them to give a substantial amount of time to district duties. There is nothing tragic in this; it simply means that they must rely on others for information and policy-making assistance.

In many cases, the SCS has provided this assistance. Although memoranda of understanding make it clear that SCS service to the district is limited to technical assistance, in many cases the SCS District Conservationist has served a greater role in program planning and administration than a strict interpretation of SCS duties would suggest; but without this assumption of responsibility by the District Conservationist or, in some cases, the Extension Agent, many districts would have been even weaker.

The failure of the district to assert full authority over the county soil and water conservation program is also demonstrated by the fact that in the past over 50% of the SWCD/SCS staff time used for providing technical assistance in Washington County was spent on ASC cost-shared projects under the Agricultural Conservation Program (ACP) (4). The decisions on which projects to cost-share were made by the county ASC committee; very limited input was provided by the SWCD.

Another weak point of the districts is that most districts have not successfully directed their manpower and financial resources (including the technical assistance of the SCS which is, by agreement, to be responsive to district direction) toward solving the most critical erosion problems in the county. Rather, the districts, through their voluntary cooperator program, have tended to provide service on a first-come, first-served basis. If farmers with the most critical erosion problems have not come to the SWCD, the SWCD has made little effort to go to them. Despite the educational, informational, and technical assistance programs sponsored by the district, the amount of land needing treatment has not decreased significantly over the past several years (4).

To become an effective resource conservation agency, the SWCD must take the very difficult step of clearly stating that farming practices which cause excessive soil loss are improper, and identifying farmers who are using these practices. Then a deliberate effort must be made to persuade those farmers to change their attitudes and practices by offering technical and financial help. This step--though it falls short of regulation--will be very difficult for districts accustomed to offending no one and to providing some degree of service to a wide clientele. If districts have not been able to secure sufficient financial support from the county board when they were providing service to many and offending no one, it remains to be seen how they will fare when they begin to make the difficult decisions connected with identifying the problem-causing landowners and proposing specific solutions to the problems.

The answer may lie in the ability of the district to expand its services to other interested groups. Thus far, most districts have not developed a clientele which includes many different interest groups; instead, the clientele has been limited almost entirely to farmers. If the district expands its services to cities and villages and if it provides further services to other groups such as Inland Lake Protection and Rehabilitation Districts, it may gain sufficient political support to offset any loss of support from farmers. Also the district might consider requesting the county board to add one or two district supervisors who are not county board members; this option is authorized under §92.06 and §59.87(2) Wis. Stat. but presently is used by only 10 to 15% of Wisconsin counties (3). For example, the district should consider requesting the county board to appoint a representative of city or village government; or, alternatively, the district itself could invite any municipality to designate a representative to advise the SWCD on issues concerning the municipality, as provided in §92.07(3). This would give the district better insight into the problems and concerns of the incorporated areas and might give the cities and villages confidence that the district would be a capable and reliable agency with which to cooperate in erosion control programs, including ordinances to control erosion from construction sites.

The district also might consider using a citizen advisory committee to obtain information and advice on county soil conservation and water quality conditions. Citizen committees have participated in the areawide water quality planning process.

In addition, consideration should be given to the appointment of a representative from the educational system; conservation education is a vital component of a long-range strategy for sediment control, and input from a school administrator or teacher could assist the district in this objective. Consideration might also be given to the appointment of a representative of an environmental organization. The objective of the district should not be to avoid conflict at all costs, but rather to encourage discussion and debate of important local issues. Decisions can then be based if not on consensus, at least on an appreciation of alternative points of view.

The SWCD has no regulatory power in incorporated cities and villages, and the authority of the district to enter into agreements to provide plans and technical assistance to cities and villages upon their request is not often used. Few cities and villages have sought SWCD assistance, although there are indications that the level of cooperation is increasing (3). If the district is to serve as a county-wide agency with substantial authority and responsibility, there must be better cooperation between it and the incorporated areas.

It should also be noted that the SWCD has no explicit authority to administer programs which have as their objective, the prevention of water pollution, except for sediment pollution. This did not present a problem for the project because we dealt only with control of erosion and sediment, but it does mean that the district will require additional authority before serving as a general nonpoint source regulatory agency. This limitation contrasts with the broader authority to prevent water pollution delegated to counties under the shoreland zoning statute (Wis. Stat. §59.971).

In Wisconsin the unique relationship of the SWCD to the county board merits discussion. Selection of district supervisors from the members of the county board (except when one or two additional members are appointed) presents special opportunities and problems. District supervisors tend to identify themselves primarily as county board supervisors, and the district as a committee of the board. This enhances the opportunity for communication and coordination of county level programs. Furthermore, since the county board generally defers to committee decisions, it would superficially appear that this arrangement would provide an effective way for the district supervisors, operating as a *de facto* committee of the board, to translate district objectives into county board policy. However, this has not been the case. In fact, this arrangement has tended to make the SWCD a more conservative body, more reluctant to push aggressively for strong district programs, because:

1. The SWCD supervisors are elected in county board elections and candidates are selected usually because of their interests in and positions on issues unrelated to soil and water conservation. In Washington County, contested elections are uncommon, and an election in which the SWCD is mentioned is rare. Successful candidates feel no constituent pressure to advocate SWCD concerns.

2. After election, the board members named to the Agriculture and Extension Education Committee also serve as SWCD supervisors. This presents an opportunity for close coordination of the two committees, but problems also emerge. Some Agriculture and Extension Education Committee members are very interested in that committee, but not so interested in promoting district business.

3. Although the board as a whole tends to defer to committee decisions, committee members are careful not to abuse the trust bestowed upon them. Thus, district supervisors are seldom aggressive advocates for special programs or funds. Such aggression would mark them as supervisors who are trying to gain power beyond that customarily accepted as appropriate. Since the SWCD is not viewed as the special governmental district which it is, but rather as another committee of the county board, district supervisors who press for assuming their legitimate authority are seen as usurping authority. Washington County supervisors, out of respect for their fellow supervisors, do not want to appear to be taking advantage of their unique SWCD authority.

In some cases an influential board member who is also a district supervisor may be able to persuade the board to provide additional funds to the SWCD and to support district programs. The board member is influential precisely because he does not abuse his power; thus, he is not likely to try to push the board very far.

Cooperative Extension Service

University of Wisconsin-Extension (UWEX) is a joint federal-state-county educational agency. Agents employed in the county generally have their salaries supported from all three sources. The county also provides office space and other support. Agents develop their work program subject to approval of the Agriculture and Extension Education Committee of the county board and the UWEX district director. Extension also has specialized staff at the state level who--independent of the county staff--provide technical support to county staff, carry out studies, and teach various aspects of water quality.

The role of Extension in sediment control in most counties is presently limited, although it could have several roles in county sediment control programs. Also, it could be involved heavily in developing expanded educational materials and activities relating to sediment control for the general public. It could be involved in organizing specialized educational activities for landowners, such as technical aspects of land management practices, issues surrounding varieties of crops, rotations, soils, etc., and farm budgeting and financial management, if significant changes in farming practices were necessary for sediment control. County extension staff generally agree that additional activity in sediment control work is possible, but it would either be at the expense of some other ongoing activity or require additional staff.

The state-level UWEX response to expansion of work in sediment control would most likely involve some growth of state-level specialist staff to train county agents, develop educational materials, assist county-level staff, and carry on direct educational programs for specialized segments of society such as the construction industry or municipal officials.

Inland Lake Protection and Rehabilitation Districts

Inland Lake Protection and Rehabilitation Districts (ILPRD) are special purpose units of government, authorized under Ch. 33 of Wis. Stats. Local property owners are authorized to form a district to protect and improve lake water quality. Technical and financial assistance are available from the Wisconsin Department of Natural Resources. The district has the power to tax, bond, borrow, or make special assessments; the budget is determined at an annual meeting of property owners within the district. A board of commissioners is selected which consists of three elected property owners, an SWCD supervisor, and a representative of the town, village, or city having the highest property valuation in the district.

There are three ILPRDs in Washington County, i.e., Big Cedar Lake, Little Cedar Lake, and Silver Lake. Water quality studies have been completed for Silver and Big Cedar Lakes, and management programs have been designed.

In many cases, the goal of protecting lake water quality requires upland management of land use practices. This naturally suggests the desirability of a relationship with the SWCD to work toward the common goal of land management in the interest of improved water quality. The potential for such a relationship is promoted by the presence of an SWCD supervisor on the ILPRD board of commissioners.

Cities and Villages

The most important source of sediment in cites and villages is from construction site erosion. Project studies regarding sediment control in these areas focused on the manner in which these governmental units could enact and administer regulatory programs.

The construction site erosion control ordinance drafted for the county affects only unincorporated areas, not cities and villages in the county. The cities and villages do have the authority, however, to enact separate erosion control ordinances. The necessity for enacting and administering separate ordinances for each jurisdiction makes it difficult to establish a reasonably uniform set of erosion control requirements across the county. In addition, it makes it necessary to convince each separate jurisdiction of the need for such an ordinance. Despite these limitations, such multiple regulations are necessary to achieve a blanket of ordinances across the county.

Towns

Towns are governmental units which cover all of the unincorporated parts of the county. Usually, but not always, their boundaries correspond to survey township boundaries (6 miles square).

It was not anticipated that the towns should be involved in a major way in enacting and administering sediment control programs for Washington County. Although towns may adopt village powers and thereby secure adequate authority to administer sediment control and other programs, the prospect of 13 towns (in addition to the two cities and five villages) enacting separate erosion control programs was opposed to the project's goal of administrative efficiency and uniformity of standards. Certainly, circumstances in which a town should exercise its authority do exist, particularly if the county refuses to take action when presented with erosion control problems. For the project's purposes, the county was the more convenient and effective geographical unit on which to base the program.

There are at least two areas in which town responsibilities are important for sediment control. First of all, four of the 13 towns in Washington County have zoning and subdivision ordinances separate from county ordinances. In the case of subdivision ordinance, however, the Washington County ordinance applies unless the town enacts an ordinance which is equally restrictive.

Secondly, the towns are responsible for the construction and maintenance of town roads. Surveys indicate that the town roads in most counties of the state have roadside erosion problems more severe than county, state, or federal highways. At the present time there are no requirements for towns to correct these erosion problems, nor is there any state support available if they do. Thus, conditions vary widely from town to town, depending mostly on the perception of the problem by town officials and their willingness to correct problems where they exist. In some counties, districts have provided equipment, materials, and labor to towns to assist in reducing roadside erosion.

Sub-State Regional Agencies

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) is the most important regional agency with responsibilities relating to sediment control in Washington County. There are at least three notable functions SEWRPC performs:

1. SEWRPC has been designated as the areawide water quality planning agency for a 7-county region of southeastern Wisconsin which includes Washington County. In this capacity, SEWRPC has played a key role in collecting and evaluating land use and water quality information, designing a plan for water pollution control, and selecting the agencies which will manage the control programs.
2. SEWRPC provides assistance to governmental units in the county in drafting ordinances and land use plans, including plans and programs to control sediment.
3. SEWRPC has provided water quality and land use information to local units of government to assist local sediment control program planning.

As a general rule, the state and federal agencies described below have multi-county regional offices. For the most part, these regional offices serve as a communication link between the state and local office, although in some cases substantial program discretion is delegated to the regional offices.

State Level Agencies

Department of Natural Resources

As the central state water quality agency, the Wisconsin Department of Natural Resources (WDNR) is responsible for the protection, maintenance and improvement of the waters of the state (Wis. Stat. §144.025). In non-designated areas of the state, WDNR has served as the areawide water quality planning agency. The agency also is responsible primarily for the administration of the state's nonpoint source grant program known as the Wisconsin Fund.

Although the authority of WDNR to enforce state laws relating to water pollution control is clear, it is much less clear what role the agency will have if regulation of land uses becomes necessary to protect and improve water quality. Land use regulation has been delegated traditionally by the state to local units of government, and it is highly unlikely that state regulation of land use by WDNR would be politically acceptable. Should regulation be necessary, the challenge will be to define a set of institutional relationships which retain regulation at local levels while insuring that WDNR is not forced to yield its position of responsibility for water quality protection. Such a relationship exists in the state shoreland and floodplain zoning program in which local governments are required to enact ordinances with minimum standards set by the state. The crucial task of administering the ordinances is handled locally; thus, local governments with limited enthusiasm for the state program may be tempted to hamper it by failing to provide adequate administrative personnel. It may be advisable for the state to financially support local administration of these state programs.

Board of Soil and Water Conservation Districts

The Board of Soil and Water Conservation Districts (BSWCD) is a state level agency with regional representatives which is primarily responsible for coordinating and assisting local SWCD programs. In addition, the BSWCD administers cost-sharing programs under Wis. Stat. §§92.20 and 92.21 which provide relatively modest assistance for SWCD staff and for the installation of practices to control nonpoint source pollution. Furthermore, the BSWCD assists the WDNR and local management agencies in the administration of the Wisconsin Fund grant program. The BSWCD is attached to University of Wisconsin for adminstrative purposes.

Federal Agencies

Soil Conservation Service

The Soil Conservation Service (SCS) was established in 1935. The 1935 legislation provided that the SCS would be the lead federal agency in programs to provide technical assistance to farmers to reduce soil erosion. Since then, SCS responsibilities have been enlarged by subsequent legislation including the Watershed Protection and Flood Prevention Act of 1954, the Rural Clean Water Program, and by the Soil and Water Resources Conservation Act of 1977.

In counties which have established a conservation district, the SCS has provided technical planning assistance to farmers and other landowners according to an agreement with the conservation district. Although rapid progress was made in installing conservation practices during its first 2 decades, in recent years the SCS and cooperating agencies have been able to plan and install only a few additionally needed practices. The rate of practice removal also has been increasing in many counties (4).

Studies in Washington County indicate that the SCS has not focused its work effort on the areas most in need of conservation but rather has tried to provide services to all who request assistance. In addition, we have found that the SCS has spent a great deal of time developing elaborate conservation plans which there is little time to implement. When the practices called for in the plan are installed by the farmer with SCS assistance, there is little attempt to follow up the practices by encouraging and assisting the farmer in maintaining them. Furthermore, there is a substantial amount of time spent in adminstrative duties, which further detracts from the time available to work with landowners to install vitally needed conservation practices. It is essential that District Conservationists, with the assistance and approval of the Area Conservationist to whom they are responsible, develop a work program which maximizes the time spent on technical assistance in priority areas. Most District Conservationists find it impossible to meet all the demands for their services, even with the most effective time management. Nevertheless, it is important that priorities be established and followed and that the District Conservationist be rewarded for the demonstrated accomplishment of these priority items.

Agricultural Stabilization and Conservation Service

The Agricultural Stabilization and Conservation Service (ASCS), among other responsibilites, administers the Agricultural Conservation Program (ACP) which provides cost-sharing funds to farmers. A wide variety of practices have been cost-shared by the ASCS over the years, but in the past many of the funds have been directed toward production-oriented practices. This has reduced the availability of funds for conservation to meet water quality goals.

Washington County receives about $50,000 annually for ACP cost-sharing. This money is allocated by the ASC county committee which consists of three farmers elected by fellow farmers. This county committee also hires a county executive director to administer the programs, but the committee makes policy and program decisions. Costs of administering the ACP and providing technical assistance for implementing cost-shared practices are fairly high, nearly equal to the amount of funds actually cost-shared (4).

All farmers in the county are eligible to apply annually for ACP cost-sharing funds. Cooperation with the SWCD is not required. Although coordination between ACP and SWCD programs is provided for through an agreement between the agencies, their programs have--until recently--developed fairly independently.

The effectiveness of the ACP has been limited by a high degree of uncertainty with respect to potential funding levels and practice eligibility. The ACP has undergone four substantial revisons in the past 8 years, resulting in confusion about cost-sharing rates and funded practices. This has made it very difficult for farmers to plan ahead for conservation.

Recently the ACP in Washington County has been directed more effectively toward high priority erosion and water quality concerns, even in light of continued high demands for production-oriented practices. In 1977 80% of program expenditures went into practices to erosion control, a much higher percentage than previously.

Environmental Protection Agency

The U.S. Environmental Protection Agency (U.S.EPA) has, as a consequence of the amendments to the Federal Water Pollution Control Act, assumed a central role in the programs related to the control of nonpoint source pollution. Areawide plans required by §208 of P.L. 92-500 are being prepared in accordance with EPA regulation, but it is not yet clear what standards the agency will require with regard to sediment. Nor is it certain whether regulation of erosion-causing activities will be required.

PROGRAMS COMPLETED IN WASHINGTON COUNTY

The development of programs for implementation in Washington County followed these general guidelines:

1. All programs must be developed with the advice and consent of local officials who would be responsible for program implementation after the project was completed. In addition, adequate consultation with these officials is necessary to adopt a program.

2. To the extent possible, ordinances should be easy to understand and administer. Landowners and other citizens have a low tolerance for complex bureaucratic regulations; failure to appreciate this fact would cause controversy and misunderstanding beyond that normally anticipated for a program of this kind.

3. Regulatory controls should not be imposed except in circumstances where lack of control allowed the continuation of practices which clearly result in excessive sediment pollution. It is not easy to define with any precision the effects of alternative land uses on water quality. For this reason we decided that controls would only be imposed where the effects could best be documented, and where standards required by the proposed regulations could be met by adopting relatively simple and inexpensive management practices.

4. Although financial and technical support from the project made program design and implementation unique, it was considered important that the programs could be adopted by other local governments without imposing an unrealistic administrative burden on other counties.

5. All programs must be within the scope of existing enabling legislation. It is expected that the Wisconsin Legislature will in the future enact legislation granting clear authority to local governments to deal with sediment pollution control. Within the time frame of this project the program design was limited to those local powers previously delegated by the state Legislature.

The major sources of sediment pollution in Washington County are construction site erosion and erosion from cropland. Development of programs to control these erosion sources focused on two basic tasks:

1. Designing ordinances to control the problem; and

2. Developing an institutional structure effectively to administer the ordinances and non-regulatory programs.

Sediment Control Ordinances

The Rural Sediment Control Ordinance

The Chapter 92 ordinance was selected as the focus for sediment control because the authority to regulate land uses to control sediment was an explicit goal of Chapter 92, and because the SWCD was considered to be the most appropriate administrative focus for the sediment control program. In addition, zoning traditionally has not been used to regulate agricultural land management practices.

Nevertheless, for certain problems particularly eroding streambanks and barnyards near waterbodies, modifications to the county shoreland zoning ordinance were drafted for consideration by county officials.

A major problem in drafting the Chapter 92 ordinance concerned the nature and scope of the requirements which should be imposed. It is possible under Chapter 92 to require that various erosion control structures be used, such as terraces, diversions, and sediment traps, or that particular cropping programs and tillage practices be observed [§92.09(5)]. This substantial authority to require specific management practices would require close supervision of individual farming practices with accompanying bureaucratic intrusion and administrative requirements.

Rather than use this approach a requirement was included in the ordinance that each farmer meet a performance standard; that is, his farm could not exceed a certain rate of soil loss, as determined by the Universal Soil Loss Equation (USLE). If soil loss exceeded the specified rate, a farmer could meet this requirement using any practices he wished as long as the predicted soil loss met the standards. This approach has several advantages:

1. The ordinance does not dictate which specific practices must be used to meet requirements; this means greater flexibility for the landowner and less government interference.

2. A "tolerable" soil loss limit has a history of endorsement as a legitimate goal from the standpoint of conserving soil and maintaining cropland productivity.

3. It sets a uniform standard for everyone.

4. Such an ordinance is easier to draft and easier to understand and administer.

5. This approach is supported by local decision-makers and particularly by SWCD supervisors.

It was also recognized that this approach has some disadvantages:

1. The uniform standard for all farmers ignores the probability that sediment from certain farms may be causing more damage, depending on the nature of the receiving body of water, than the same amount of sediment from another farm. In addition, eroded soil from farms distant from a waterbody is less likely to reach the water than soil eroding from a farm adjacent to the waterbody. Furthermore, the approach fails to consider that natural buffers along the waterway could protect it from soil eroding from a nearby field.

   A partial solution to this problem is the proposed development of a list of priority areas in which sediment reduction was considered to be most effective in decreasing pollution. Since manpower to administer the ordinance was limited, the idea was to approach these critical areas first, insuring that farms in these areas met the standards. This combination of a uniform standard and discretionary administration was the most practicable method.

2. The USLE is not applicable to barnyards, streambanks, and gullies. These crucial problem areas contribute substantially to the sediment problem. Amendments to the county shoreland zoning ordinance were drafted in an attempt to deal with some of them (5).

3. Farmers in hilly areas, especially in areas with highly erosive soils, would find it more difficult to reach the standard than would a farmer owning less erosive land. Therefore, some farmers could have a greater financial burden than others, but they could also receive a long-term benefit by keeping productive soil in place.

4. Farmers on less erosive soils, who could cost-efficiently reduce soil loss below 3 tons/acre/yr (6 tonnes/ha/yr), would have no incentive to do so.

The soil loss limits set by the ordinance are a long-term average of 3 tons/acre/yr (6 tonnes/ha/yr) for the entire farming unit and 9 tons/acre/yr (18 tonnes/ha/yr) for any given 200 square feet area (approximately one acre). The 3 tons/acre/yr (6 tonnes/ha/yr) was set because studies indicated that compliance would yield significant sediment reduction with reasonable cost burdens to farmers (7). The 9 tons/acre/yr (18 tonnes/ha/yr) limit was established to eliminate the possibility that a farmer might meet the 3 tons/acre/yr (6 tonnes/ha/yr) limit as an average for his farm and yet have a particular piece of land which had a very high rate of soil loss.

The requirements of the ordinance are not hard to meet. Investigations indicate that only 10 to 20% of Washington County farmers would be required to make some change in farming practices, such as a change in crop rotation, to meet the standards. Other farmers would not be affected at all. In addition, it was found that for a typical noncomplying dairy farm, net income would be substantially unchanged after the farmer comes into compliance with the ordinance (6). The burden of compliance is further lessened by the fact that if capital expenditures are required for compliance, at least 50% cost-sharing must be available to the farmer before he needs to meet the requirements. Furthermore, low interest loan programs and tax benefits are available to farmers who install conservation practices (7, 8).

The ordinance was designed to be administered by the SWCD efficiently and non-intrusively. No farmer would be required to take any action unless the SWCD completed an inspection and, by using the USLE determined that soil loss for this farm exceeded the limits. In that case the farmer, or the SWCD if the farmer so requested, would be required to complete an erosion control plan (less extensive than an SCS conservation plan), and to comply with this plan. However, if the farmer had a district-approved conservation plan on file he would be presumed to be in compliance for 5 years after the plan was approved. In addition, the SWCD could approve a variance from the requirement of the ordinance if conditions warranted. Penalties for noncompliance with the ordinance are not severe. If a farmer is required to submit an erosion control plan and he does not do so, he can be fined $5/day for each day he is late, up to $100. Negligent failure to follow the plan is punishable by a fine up to $100. Blatant and willful disregard of the requirements is punishable by a fine up to $100/day for each day of noncompliance. The district or any owner of real estate in the area affected by the ordinance may enforce compliance with the erosion control plan by obtaining an injunction from the circuit court.

Chapter 92 imposes several procedural conditions for an ordinance of this type. First of all, the ordinance, although proposed by the district, must be approved in a referendum by the people who live in the area to be affected by the ordinance. This is a substantial obstacle since voters are not inclined to support regulations in general, and are even less likely to approve a regulation concerning a subject about which they had very little knowledge (9). The lack of awareness of sediment problems and of nonpoint source pollution in general, mandates a substantial educational and informational program (see Part III).

Secondly, the ordinance, if approved by the electorate in the referendum, also must be approved by the county board. In Washington County this was not considered a major problem since the district supervisors are themselves county board members and as a committee of the board traditionally demonstrate some influence on the board as a whole. In addition, it the residents of the area approved the regulation it would be unlikely that the county board would reject it.

Thirdly, Chapter 92 allows the SWCD to design the area affected by the ordinance to include all or any part of the unincorporated part of the county. Incorporated areas would not be covered by the ordinance and other parts of the county could be excluded apparently for any reason. This suggests that the ordinance could be limited to areas with the worst erosion problems (which might make passage less likely), or that it could include areas with less severe problems and also include areas with non-farm landowners, who might be more likely to approve the ordinance. In Washington

County, as a whole, the non-farm population in unincorporated areas far exceeds the farm population. Thus, the possibility exists that an ordinance could be approved in a referendum even though none of the farmers to be affected voted for it. To avoid this problem and to give the affected farmers a meaningful voice in the referendum, the area affected by the ordinance could be limited by excluding the unincorporated areas inhabited by non-farm residents. The obvious disadvantage of such limitation is that the farmers--as self-regulators--would most likely approve no regulation at all. Furthermore, rural non-farm residents, as well as urban residents, have a real interest in water quality and should have a voice in pollution control programs.

Shoreland Zoning Ordinance Amendments

The Chapter 92 ordinance was the focus of efforts to induce sediment control regulation in Washington County. To complement this ordinance, it was proposed that the Washington County shoreland zoning ordinance, enacted in accordance with Wis. Stat. §59.971, be amended to provide erosion controls. In general, the objectives of these proposed revisions include the prevention of highly erosive tillage practices along lakes and streams, the prohibition of cattle access to easily erodible streambanks, the control of pollution from barnyards and feedlots within the shoreland zone, and the prevention of manure and fertilizer spreading on frozen ground when the manure or fertilizer would run off into navigable waters.

Although erosion in the area for which shoreland zoning is applicable [300 ft (100 m) from rivers and streams and 1000 ft (325 m) from lakes] is a major contributor to water quality problems, the shoreland zoning approach has several drawbacks:

1. As with all county zoning ordinances, shoreland zoning ordinances exempt uses which do not conform to the ordinance at the time it is enacted. Thus, future land uses may be regulated while nonconforming uses are not controlled, unless they are discontinued for a 12-month period.

2. Zoning has not traditionally been used to control farming practices within the area zoned for agriculture (5). Such zoning regulations may be legally permissible, but the Chapter 92 ordinance seemed to be more politically acceptable.

3. Shoreland zoning, by definition, affects only a limited part of the county. Thus, farmers in the shoreland zone are subject to stricter requirements than those in non-shoreland areas. The argument can be made that this merely insures that those people causing the most pollution are those on whom the regulations are focused. However, many local officials disagreed with imposing different requirements, particularly with regard to cropland erosion control.

4. The administering agency for shoreland zoning in Washington County is the Park and Planning Commission which competently administers that program. Nonetheless, the greatest source of expertise regarding agricultural problems, however, lies with the SWCD.

Fate of the Ordinances

Neither the Chapter 92 ordinance nor the amendments to the shoreland zoning ordinance have been adopted. The Chapter 92 ordinance faces a difficult test (SWCD approval, referendum approval, and passage by the county board). To overcome opposition, an extensive informational and educational campaign as well as consultations with the supervisors of the SWCD was initiated.

This work proceeded in the belief that the areawide water quality plans required by §208 of P.L. 92-500 would call for regulation of agricultural nonpoint sources of pollution, unless it could be demonstrated that voluntary programs would be effective (such a policy was indicated by the U.S. EPA memorandum SAM-31). It was the general understanding among Washington County officials that while the Washington County regulatory program would be enacted in advance of regulations in other areas and thus would provide a valuable demonstration of the effectiveness of a certain type of regulation, other areas of the state and county would soon be required to follow with regulations of their own or face a state or national mandate for regulations. There was little indication that the 1983 and 1985 goals established by P.L. 92-500 could otherwise be reached.

As the areawide water quality planning proceeded, however, suggestions were made that there would be no such requirements, at least not in the foreseeable future. This sentiment was indicated informally in the letters and speeches of the U.S. EPA Administrator (10). In addition, the Wisconsin Legislature enacted a statute (Wis. Stat. §144.25) intended to control nonpoint source pollution through a voluntary program with a provision that an evaluation of the effectiveness of this type of approach be completed by 1982. Such actions made Washington County officials skeptical that regulation of agricultural sources of sediment pollution would be required by state or federal law in the foreseeable future.

Given these circumstances and the fact that public opinion in Washington County did not appear nearly ready to approve the proposed regulations, the Washington County SWCD decided in early 1978 not to recommend the ordinance for enactment. The supervisors were reluctant to propose a regulation which was almost certain to be defeated. Surveys indicated that awareness of nonpoint source pollution in Washington County was not high enough to make passage likely, even after the extensive informational effort. In addition, it was felt that the chances for future enactment of ordinances would be reduced if this one was defeated decisively.

Thus, no rural ordinance was enacted. In its place, however, the SWCD adopted and the county board passed a resolution which incorporates the objectives and standards of the regulatory ordinance. While there is no authority to compel compliance, this resolution serves three purposes. First of all, it shows that local decision-makers are aware of the sediment problem, they recognize changes are needed to solve the problem and they endorse the standards required by the ordinance. Secondly, the ordinance provides the SWCD with an additional incentive and justification for identifying erosion-causing land use practices and the responsible landowners. Thirdly, the SWCD, using this policy statement as a guide, will be able to test the administrative procedures and the feasibility of the soil loss standards which would have been used under the ordinance.

Thus, an adminstrative procedure can be designed which is similar to that which would have been employed had the ordinance been enacted. However, since no authority exists to require compliance with the standards, the SWCD will need to rely on its powers of persuasion and the availability of limited cost-sharing funds to induce compliance.

The revisions to the county shoreland zoning ordinance also have not been adopted, although the Park and Planning Commission has given them serious consideration. These revisions basically were considered to complement the Chapter 92 ordinance, and they were not examined thoroughly by the county board until after it became clear that the Chapter 92 ordinance could not be enacted. The county may shortly be enacting some amendments to its shoreland zoning ordinance to regulate erosion and other nonpoint sources of pollution.

Subdivision Erosion Control

The subdivision erosion control ordinance is intended to control sediment by requiring review and approval of all plats and certified survey maps by the SWCD (5). This procedure requires review by the SWCD within the same time frame allowed for plat review by other reviewing authorities acting under the authority of Wis. Stat. Ch. 236. Thus, no additional delays occur, provided the plat meets erosion control requirements.

Chapter 236, under which authority the county and certain other local government bodies may review plats, does not provide explicitly that compliance with soil and water conservation standards may be used by local governments as a requirement for plat approval. The chapter does provide, however, that approval of a plat shall be conditioned upon compliance with any county ordinance [§236.13(1)(b)], and we considered this to be adequate authority.

These requirements are fairly modest. They include a land suitability test. Sites with a slope of 12% or greater are presumed unsuitable for development, unless the developer can show that potential erosion and sedimentation problems will be eliminated. Secondly, the ordinance requires that stormwater management facilities be constructed to accomodate maximum potential flow from a 10-yr, 24-hr storm. These facilities must be designed to retard, temporarily store or allow infiltration of stormwater runoff to prevent downslope erosion. They must also be consistent with existing county and areawide hydrology plans. Thirdly, conservation practices are required to minimize soil erosion and sedimentation if substantial cutting, grading, and other land disturbing activity is carried out during development.

The procedure for enacting this ordinance is less complex than that used for the Chapter 92 ordinance. In this case, the substantive portions of the ordinance were drafted and incorporated into the existing Washington County Land Division Ordinance by the Washington County Corporation Counsel with review and recommendations provided by the Washington County Project. The Washington County Park and Planning Commission and the SWCD took active roles in the design and promotion of this ordinance. With the endorsement of these two groups the erosion control amendments were enacted by the county board without a dissenting vote in June 1978.

Penalties for violation of the erosion control part of the ordinance are the same as for violation of any other part of the land division ordinance. Failure to comply with the terms of the ordinance may result in a fine of $25 to $200/day. Compliance also may be enforced by an injunction.

Although the ordinance has been enacted by the Washington County Board of Supervisors, and administration is proceeding without undue difficulty, there are two areas which need some improvement. Firstly, informational brochures and guidelines for developers on ordinance requirements and how best to meet these requirements need to be written. Secondly, administration of the ordinance requires a substantial time investment by SWCD staff. The SWCD has expanded its staff, however, and when techniques for review of plats are perfected, the time required for each review is expected to decrease.

Although this ordinance was designed to control erosion from most construction sites in the unincorporated parts of the county, there are some situations in which it is not effective. For example, if the subdivider whose plat or certified survey is reviewed has no intention of developing at the present time, but instead sells the lots for development by others, the ability to regulate the actions of the subdivider is meaningless since he will not develop the lot. In addition, there are some developments for which neither a plat nor certified survey is required, e.g., where there is no subdivision of land. A subdivision is defined as a land division creating 5 or more parcels of 1 1/2 acres (.6 ha) or less within a 5-yr period. [Wis. Stat. §236.02(8)]. If there is no subdivision, or if no certified survey map is prepared, the development may escape the requirements of the ordinance.

It is too soon to assess completely the effects of the passage of the construction site erosion control ordinance. At this point such a measure seems to be feasible politically. It can be administered without excessive difficulty,, and in general has the cooperation of developers. As a result, this kind of control appears to be highly beneficial at limited public and private cost.

Subdivision Erosion Control in Incorporated Areas

The county erosion control ordinance described above does not affect the incorporated parts of the county. To achieve the goal of a reasonably uniform set of erosion control requirements for subdivisions, it is necessary for cities and villages to enact similar ordinances. So far, four of the seven cities and villages in the county have enacted, or are in the process of enacting, or are considering such an ordinance. In general, the provisions of these ordinances are similar to those of the county ordinance, except that the cities and villages use their own engineers (or hire consulting engineers) to review the plats and certified survey maps. In some cases, the SWCD is included as an agency from which advice and recommendations may be solicited, but the SWCD does not yet have meaningful review of the developments in most incorporated areas.

Administering a Sediment Control Program

Coordinating Local Programs

In the previous section the many agencies which have responsibility for programs dealing with sediment control were discussed. A major project objective was to coordinate the programs in Washington County in order to obtain reasonably effective direction of the sediment control programs. Minimally, this meant that the authority for and resources available to the various agencies needed to be defined, coordination of the programs needed to be promoted wherever possible, and in some cases new inter-agency relationships needed to be designed.

Although several agencies were involved in programs which were clearly related to sediment control, the goal of sediment control in the interest of water quality was not pursued actively. Traditionally, responsibility for water quality protection was exercised by state and federal agencies, and responsibility for control of land uses was held at the local level. In the future, effective sediment control programs in the interest of water quality will require that these two previously separate functions be united, if not under the jurisdication of a single agency, then by a combination of agencies working cooperatively toward a common goal. Such a program is not unique. Wisconsin's shoreland and floodplain zoning programs already serve as a model of state requirements of land use control for water quality protection with the control programs administered locally. These programs, however, require the joint efforts of the WDNR and either the county zoning agency for county shoreland and floodplain ordinance administration or the city/village zoning office for administration of the floodplain zoning program in the incorporated areas. The sediment control program will involve the WDNR and several other agencies.

Several organizational alternatives were considered in the search for the most advantageous combination of agencies operating at the county level. It was concluded that at the very least the SWCD, SCS, ASCS, University-Extension and the Park and Planning Commission should be involved. Furthermore, it was decided WDNR, SEWRPC, ILPRD, and the county, cities, villages, and towns should be involved. Several patterns for coordination emerged:

1. Staff level coordination would involve the SWCD staff, SCS District Conservationist, Extension agents, ASCS county executive director and the Land Use and Park Administrator. Interaction would be based on the particular programs involved. Determination of priorities for cost-sharing and technical assistance would require information from all agencies. In other cases, such as administration of the erosion control amendments to the county land division ordinance, close interaction of the SWCD and Land Use and Park Adminstrator would be essential with the input of the other agency staff more limited. This approach presumes a desire to cooperate on the part of the various agencies, and, of course, acknowledges that final policy decisions would, in all cases, be made by the committee, board or officer to whom that responsibility has been delegated.

2. Using shared committee membership some or all of the relevant policy making bodies (SWCD Supervisors, ASC Committee, Park and Planning Commission, Agriculture and Extention Education Committee) would share one or more members or use members of the other committees as advisors. This kind of arrangement already exists to a substantial degree and the Extension Committee has the same membership as the SWCD. The ASC Committee, under an agreement, holds joint meetings with the SWCD as least annually in addition to the annual program development meeting. The important relationship, which does not yet exist, is a closer tie between the SWCD and the Park and Planning Commission. This could be solved by adding a non-county board member of the Park and Planning Commission as a sixth member of the SWCD supervisors, under the provisions of Wis. Stat. §92.06.

3. The Washington County Board could establish a formal joint committee by appointing the same board members as the members of the SWCD and the Park and Planning Commission. These board members would then have jurisdiction over the SWCD, Extension, and the county zoning and subdivision ordinance programs, although they would continue to exercise their authority through the separate committees. Seven counties in Wisconsin have such an arrangement (11).

4. A water quality and land use advisory committee, which would consist of representatives of all of the major agencies listed above, could serve as a center of information exchange and program coordination. Its decisions and recommendations would be advisory only.

Each of these alternatives was proposed at one time or another to the Washington County officials. Ultimately, parts of alternatives 1 and 2 have been adopted. Alternative 3 would have required a major revision of county committee structure, and it was not clear that the advantages were substantial enough to merit such a change. Alternative 4 was rejected as being unnecessary and needlessly time-consuming, since most of the functions envisioned by this arrangement are already performed at the SWCD annual meeting or ACP development meeting of the ASCS.

Selecting a Management Agency

An examination of the available options suggested that the Washington County Soil and Water Conservation District (SWCD or district), rather than the county board, was the most appropriate focus for project activity in the unincorporated areas. The individual cities and villages could best handle the sediment problem in the incorporated parts of the county. This decision was based on these reasons:

1. The Wisconsin Legislature, in Chapter 92 Wis. Stat., has delegated to the SWCD the responsibility for county level sediment control programs, and particularly for regulatory sediment control programs (§92.09). The county, on the other hand, has no explicit authority to enact and administer a sediment control program except for those land use regulations which are proposed by the SWCD. Nonetheless, the county has some powers which might be used. The county is required to enact a shoreland zoning ordinance which arguably could be used to control land uses which cause excessive sedimentation in the limited shoreland zone. The county could also use its traditional zoning authority to achieve similar ends. Furthermore, the county could use its building and sanitary codes for sediment control. However, the authority for a county to enact a sediment control ordinance is not explicit. In fact, §92.15(2) provides that if an SWCD is discontinued by the county board, "the county board may not pass any more ordinances adopting land-use regulations or effecting changes in such an ordinance previously adopted . . ."

   This provision may mean that any land-use regulations controlling sediment from agricultural sources may only be enacted through the Chapter 92 process.

2. Although the SWCD regulatory authority does not extend to incorporated areas, Chapter 92 does provide that the SWCD may provide plans, standards, and technical assistance to cities and villages upon request. Thus, the SWCD could not only manage the county programs, but could have an advisory role in incorporated areas as well, thereby promoting the project objectives of providing uniform and efficient administration of sediment control programs.

3. The Washington County SWCD supported the objectives of the project, and was small enough in size (five members) to allow easy and substantial exchange of ideas during the ordinance drafting process. Furthermore, its members also were county board members, and this furnished a practical and effective way to transmit project ideas to the board.

4. The sediment control program would involve cost-sharing and educational programs as well as regulation, and the existing relationships between the SWCD, SCS, ASCS, and University-Extension would promote a coordinated program.

5. The SWCD, with the assistance of the SCS, had the best technical conservation expertise.

6. The SWCD, since 1943 in Washington County, had worked cooperatively with farmers to develop conservation programs. This alliance with farmers made it likely that the SWCD would be willing to promote only moderate regulations, but, as discussed above, even the relatively modest regulations, properly administered, would control most of the problem. On the other hand, severe regulations administered by an agency unfamiliar with farmers could neither be enacted nor effectively administered.

7. Cities and villages were the logical managing agencies for programs within their jurisdictions. They have broad police power, thus clear authority to enact the programs. They also have the authority under §66.30 to enter into cooperative agreements with other governmental units should such cooperation be desired; §92.08 also allows muncipalities to enter into limited cooperative agreements with SWCDs.

The formation of special districts for each problem the government is called upon to address, is not encouraged. In the case of sediment control,however, the SWCD, although possessing some of the features of a special district, is tied very closely in a legal sense to the county board. In reality the Washington County SWCD serves almost as a committee of the county board. Its boundaries are the same as the county boundaries; its members are selected from the members of the board; and--having no taxing authority--it is dependent on the county board for locally-derived revenue. Furthermore, only the county board may create or discontinue a district.

There is a vital relationship between the county and the district. The cooperation of the county board is essential if an effective nonpoint source pollution control program is to be developed; but for the limited sediment control program, it was decided to focus the sediment control programs on the district.

Use of the SWCD as the focal agency places emphasis upon the relationships the SWCD has with other agencies in Washington County. Some of these are as follows:

1. The SWCD-Park and Planning Commission relationship has been particularly important in the development and administration of the erosion control amendments to the land division ordinance. The SWCD and Planning Commission jointly developed, held hearings on, and endorsed this amendment for county board approval. Now after its passage, they are developing procedures for efficient administration of the ordinance. This relationship is also important with regard to the shoreland zoning amendments to control sediment and other nonpoint source pollution. These amendments have not yet been adopted, and may not be enacted. However, the two committees have discussed general objectives of the revisions and further cooperation is anticipated. If the provisions relating to control of soil loss in the shoreland zone are enacted, the administering agency (Land Use and Park Department) would probably rely closely on the SWCD for assistance.

2. The SWCD has close relationship with the SCS in Washington County, as it has in most counties. The SCS has provided the SWCD with vital soil conservation expertise and has--in some cases--provided the SWCD with administrative and policy-making assistance as well. It is not likely that these latter functions are within the scope of agreement signed by the two agencies. It is also possible that where the SWCD decides to hire staff for administrative purposes, a conflict may arise with the SCS District Conservationist over administrative responsibilities. This is a delicate problem which will probably have to be handled on a county by county basis, although the state and area representatives of the two agencies may provide assistance in reaching an agreeable solution. In any case, the relationship has been and will continue to be crucial for both agencies.

3. The SWCD-ASCS relationship is important because the availability of cost-sharing assistance for landowners is imperative whether a voluntary or regulatory sediment control program is pursued.

   In large measure, this has been supplied traditionally by the Agricultural Conservation Program (ACP) of the ASCS, although in recent years, other federal and state cost-sharing programs have been devised. The ACP will continue to be important, however, and therefore the agreement between the SWCD and the ASCS, which recognizes the common objectives of the conservation of land and water resources, is important. When the SWCD identifies the areas and practices causing the most water quality problems, it would be beneficial if the SWCD, in addition to providing SCS technical assistance, could also induce the ASCS to allot some cost-sharing funds to the identified landowners. The agreement between the agencies does generally provide for such coordination, but it has not been rigorously observed. During the past year, however, the ASCS has focused much more of its cost-sharing money on practices designed to improve water quality suggesting that a closer relationship between the two agencies may emerge.

4. The SWCD and Inland Lake Protection and Rehabilitation Districts have mutual objectives. In Washington County, the SWCD and Big Cedar Lake District have signed an agreement which calls for the completion of a comprehensive management plan for the Big Cedar Lake watershed, and for the implementation of practices needed to provide sufficient control of erosion to protect the quality of the lake. Thus, the lake district's objective of reducing pollution in the lake can be aided by the SWCD performance of traditional planning and technical assistance to landowners.

5. The relationships between the SWCD and incorporated cities and villages arepresently the weakest of the relationships discussed. Although the SWCD is authorized to provide assistance to municipalities [§92.08(2) and §92.08(4)(e)], municipalities have rarely requested such assistance. This is changing somewhat in Washington County since the SWCD has a primary role in the administration of the county subdivision ordinance. Although this ordinance does not affect incorporated areas, some of the municipalities will be relying on the SWCD for assistance in drafting and administering their own erosion control provisions to their subdivision ordinances.

Manpower Needs

The above sections describe an institutional arrangement and the legal tools which are considered desirable in reaching sediment control goals. Unanswered is the question of which individuals in these agencies should be responsible for which tasks, and, further, how much time will be needed to complete these tasks.

Project research indicates that manpower to implement the proposed sediment control program in Washington County is inadequate, both in the number and training the personnel. Only recently has the Washington County SWCD hired its own full-time staff person. A backlog of several dozen requested but uncompleted conservation plans exists at the SCS office, and more requests are expected as farmers move to comply with the requirements of the Farmland Preservation Act. This law requires that to be eligible for tax benefits farmers must be in compliance with an SWCD approved farm plan. It is possible, however, that a better determination of priorities and improved time management could significnatly improve the output of the agencies working on present programs.

For an expanded sediment control program to be administered effectively the following steps are necessary:

1. Recognition by state and federal agencies that the key to the success of a voluntary or regulatory program lies at the local level. Well-trained soil conservationists (and some farm management specialists), who through performance have gained the respect of farmers, will be much more effective in convincing farmers to implement the needed management practices than will staff from state or regional agencies. The farmer's willingness to make the needed changes is essential for a program's success.

2. State financial assistance for manpower should be given to local agencies. These local agencies should have considerable discretion over the hiring and work program of the employees. Information and assistance must be provided to these local employees by state agencies, but in general the state role should be more supportive than directive. It is suggested that the most effective way to reduce sediment and other nonpoint source pollutants--especially from agricultural sources--is to make maximum use of local government agencies.

3. Many people working at the local level (including federal employees) are not adequately trained in the areas which are crucial to solving sediment pollution problems. Some of these areas include methods to control construction site erosion; an understanding of the maze of institutional arrangements inevitably involved in sediment control programs; farm management alternatives which could reduce cropland erosion; and alternatives to cost-sharing such as loan and tax deductions, which could reduce the cost to the farmer of implementing best management practices. New and existing training programs should consider these needs.

4. A short term program to identify and control sediment and other nonpoint pollution sources may be helpful, but it should not be viewed as the total solution to the nonpoint source pollution problem. A set of continuing conservation programs should be established in all parts of the state, not only in those selected for priority attention at this time. To obtain the required professional personnel to manage these programs, an additional investment in manpower is needed.

5. If a more aggressive campaign to locate and convince the worst pollutors to use alternative management practices is adopted, human relations skills will be needed. Under the best of circumstances it is a major challenge to convince farmers, developers

and others of the need to use sediment reducing practices. If agency representatives are insensitive to the legitimate economic concerns of the farmer or developer, however, farmers will be unlikely to cooperate.

Focusing Institutional Resources

It was found that the best way to improve water quality through changes in land management practices involves a "critical areas" or "worst-first" approach. By focusing resources (planning, technical assistance, and cost-sharing) on areas with high levels of erosion and sedimentation, the maximum improvement in water quality for each public dollar invested will be obtained. In addition, it is generally suggested that attention be given to the quality of the waterbody for which improvement is desired. It may be that for some waters even a substantial reduction of sediment would have little effect, while for other waterbodies a relatively small sediment reduction could effect a substantial improvement in water quality and would probably be the most cost-effective.

Hence, an obvious pre-condition for the implementation of a "critical areas" approach is knowledge of the water quality of the streams and lakes of the county, as well as information on soil types and land uses. A substantial effort has been made in Washington County to determine the types of information now available and to collect and integrate this into a useful form for county decision-makers (12, 13). This information included data from the Conservation Needs Inventory (CNI) which details land management practices on a random 2% sample of county land; the SCS soil survey; the SCS 99 Report summarizing the extent of conservation practices in the entire county; and the SEWRPC land use inventory. In addition, information on the quality of the waters in the county has been collected and related to the land use information. Most of this information has been collected from other agencies, but it has proven useful to pull it together in a meaningful fashion. In a series of meetings, this information was presented to the SWCD supervisors in Washington County.

In addition to basic land use and water quality information, it is essential to get information on public concerns and priorities regarding water quality. Extensive surveys of Washington County have been conducted, and a series of meetings have been held across the county to elicit information from the public. This information is being evaluated as priorities for county sediment control programs are established.

Information available to the county decision-makers is much better now than it was a few years ago, but areas still exist needing improvement. For example, the 2% survey is too limited in its coverage to give more than a general idea of land management practices and needs. Also, more detailed information is needed, both at the county level to aid in the selection of watersheds on which to focus resources, and at the watershed level, to determine which specific areas are causing sediment problems.

Information collection is not only a vital component of a program to focus resources, but is also necessary for the effective management of agency staff and programs. In preparing its long-range and annual plans, the Washington County SWCD has recognized that it has limited resources and that not all of the programs can be completed. Therefore, in selecting which programs are most important, the SWCD has focused on those which have the greatest potential for water quality improvement. Other programs, such as drainage of lowlands, although popular with landowners, have been downgraded in importance. The SWCD has also in the past year improved its coordination with the SCS Annual Plan of Operation (APO) by holding its planning meeting at the same time of the year as the APO is prepared. The APO for the SCS in Washington County also emphasizes the need for land treatment in priority areas. Furthermore, ASCS has responded to the need for emphasizing water quality practices in the distribution of ACP cost-sharing funds, although it does not appear that the state allocation of funds to the counties is based on the relative needs of each county for practices to improve water quality.

It is too soon to evaluate the effectiveness of these programs. The response of county agencies (and federal agencies operating at the county level) to the need to focus resources on prioirity areas is commendable, but we do not yet know whether the agencies will be able to make the very difficult decisions required to keep the programs focused on the selected priorities.

IMPLICATIONS FOR FUTURE SEDIMENT CONTROL PROGRAMS

Federal and State Policy Effects on Local Regulations

One objective of the project was to determine whether local governments, given federal support, would be willing to enact regulatory programs to control sediment. At the beginning of the project, local officials shared the widespread belief that a regulatory program for control of sediment from construction sites and farmland would be required in order to meet the national goal of fishable, swimmable water by 1983. These requirements would be in the form of state law induced by federal sanctions, in particular, by the withholding of federal grants for municipal facilities construction. While Washington County was offered incentives in the form of assistance in designing and implementing the program, the threat of federal or state mandated controls was perceived to be near at hand. Washington County officials saw the project as a demonstration of which form of politically-acceptable regulation would lead to measurable sediment reduction. Results of the study would help federal and state policymakers devise feasible regulations for sediment control.

Midway through the project, perception of the imminence of state or federal requirements for regulations changed. Whether this change was a correction of a misperception, or whether the position of state and federal officials changed is not important. It is important to note that as the likelihood of a federal or state mandate for regulation diminished, the willingness of local officials to enact a regulatory program decreased. The regulatory program for control of erosion from farmland, a central objective of the project, was originally supported in concept by the Washington County Board of Supervisors (Washington County Board Resolution No. 53-73-74, Nov. 1, 1973). This program was developed with the advice and support of the Washington County Soil and Water Conservation District, but was rejected by these local officials when it became clear that regulation of sediment from farmland would not be required at the state or national level, at least in the near future. Instead of regulation, the voluntary approach to farmland erosion control was endorsed by areawide water quality plans, and by the Wisconsin Legislature in the Wisconsin Fund grant program (Wis. Stat. §144.25), at least until 1982 when an evaluation of voluntary programs in Wisconsin will be completed. Washington County officials were not willing to consider the imposition of regulations, however modest, on their county's farmers unless there was a reasonable prospect that farmers in other areas would be required to operate under similar restraints.

We learned from this experience that projects of this kind are handicapped by the lack of a consistent and clear national and state policy for sediment control. It is understandable that a precise national policy is difficult to formulate because technical information on the water quality impacts of sediment is lacking and assessment of the costs and benefits of sediment control is inadequate. Thus, the Congress, in establishing the areawide planning process under P.L. 92-500, adopted a flexible approach to controlling sediment and other nonpoint sources of pollution. Nonetheless, the credibility of state and national agencies is diminished when these agencies are perceived to be on a shifting and uncertain course.

Likelihood of Local Enactment of Sediment Control Regulations

The Washington County experience suggests that local governments will enact regulations to control sediment only in limited circumstances. In enacting the county construction site erosion control ordinance, the county board showed that it would enact an ordinance which required limited added administrative expense, which would control recognized erosion problems, and which added a small cost to developers and home buyers.

Conversely, the county was not willing to proceed with the rural erosion control ordinance. Although research suggested that additional costs to farmers would be low, and that only about 10 to 15% of county farmers would have any additional requirements to meet, the perception among local officials was that the ordinance would impose an added cost on the county and--at least--on some farmers. Furthermore, local officials did not perceive a benefit to match this added cost. Instead, they saw that the farmers in this county would be required to operate under an additional handicap, putting some of them at a competitive disadvantage with farmers from other parts of the state. Thus, if state or national policymakers eventually consider that a need exists to regulate farmland erosion, incentives in the form of minimum statewide standards must be set. Studies suggest that Washington County is not unique in its policymaking behavior (14). We suspect that if Washington County was not ready to regulate farmland erosion, few other counties are likely to do so without greater incentives than were present in Washington County. A program similar in design to the Wisconsin shoreland and floodplain zoning program in which the state sets minimum standards and the county (or city or village) administers the program may be successful.

Need for Local Administration of Sediment Control Programs

Despite the unwillingness of local officials to proceed with the proposed rural ordinance, local officials are highly competent and conscientious. Although this report has indicated what was perceived to be some shortcomings at the local level, it is felt that the local government administration in Washington County is as competent as that at any level of government.

Local officials are the key to a successful sediment control program. These programs demand a close acquaintance with local land use conditions and with landowners and developers. A large measure of the success of any program will come from inducing farmers and developers to cooperate willingly in promotion of sediment control goals and programs. Local agency personnel, who understand local conditions, will be far more successful in securing this cooperation than will representatives from agencies at other levels of government.

No doubt observations similar to these have been made countless times, yet it continues to appear that whenever programs are designed to combat sediment problems, local personnel needs are the last to be considered. Sediment control programs will stand or fall on the ability of local officials and agency personnel to handle the problem. Future sediment control programs, at whatever level initiated, must recognize this fact. When funds for administration of sediment control programs are allocated, the first priority should be for local technical and administrative assistance.

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PART II

TECHNICAL UNIT
FINAL REPORT

by

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SUMMARY OF GOALS, METHODOLOGY AND FINDINGS

Goals

The primary goal of the Washington County Project technical unit was to demonstrate the relationship of certain land uses to water pollution and--in specific areas--to determine the effectiveness of several sediment and erosion control techniques for improving water quality (1). The major objectives were:

1. To measure the amount of water and the concentrations of sediment and associated pollutants in surface runoff from agricultural and urbanizing areas, and to compute pollutant loadings;
2. to identify those characteristics of different land uses and management practices that contribute to sediment-related water pollution problems;
3. to investigate the effectiveness of erosion control measures in reducing runoff and pollutant discharges from specific agricultural sources--particularly cropped fields and barnyards--by using a "before and after" treatment approach;
4. to examine methods for reducing soil erosion and sedimentation from housing construction in a residential subdivision.

Methodology

Runoff monitoring stations were established in an agricultural area near Kewaskum and two subdivisions under construction near Germantown in Washington County, Wisconsin. Water samples from these areas were collected during runoff events. Samples were analyzed and relationships between precipitation, runoff, land use and water quality were investigated. Farm management practices, both traditional and innovative, were implemented and their effectiveness and acceptability were evaluated. Methods of controlling erosion from residential construction sites were studied and recommendations made on what provisions should be included in a subdivision erosion control ordinance.

Supporting projects provided information on how to improve the monitoring system. Computer models and predictive tools were developed and/or modified to help highlight the policy implications of agricultural management alternatives. These models were tested with monitoring data from the Kewaskum watersheds.

Findings

1. Data were collected and analyzed for two years from eight monitoring stations in the agricultural and developing residential watersheds in Washington County. In addition to providing valuable technical information, these stations served as focal points for the Project's Washington County based information and education programs. They also helped increase public awareness of sediment and related water quality problems and public acceptance of institutional and technical control alternatives.

2. Well-managed croplands on dairy farms showed relatively low sediment and nutrient losses. Contour strip-cropping proved to be a highly effective sediment and nutrient control practice on steep-sloped croplands. The water quality benefits of grass waterways and subsurface drainage systems in relatively flat watersheds, however, were questionable.

3. Unmanaged barnyards were the largest contributors of pollutant loads in the dairy farming watersheds. The experimental management system installed in one watershed demonstrated that effective management is possible.

4. Sediment carried most of the phosphorus and nitrogen measured in runoff from rural and urbanizing sites. However, land management practices could successfully reduce loads of sediment and their associated pollutants, although dissolved loads were often increased.

5. Excessive sedimentation and other water quality problems associated with intensive housing construction were documented. Pollutant concentrations and loads diminished as the monitored subdivisions stabilized. Erosion control alternatives were identified but the effectiveness of the control measures were not successfully demonstrated during the most critical phases of development.

6. The feasibility and acceptability of conservation tillage practices were evaluated in detail. "No-tillage" has been poorly received in Wisconsin. On research plots in Washington County technical limitations were observed with the "no-tillage" system. Other reduced tillage systems, in particular chisel-plow systems, showed greater promise. Water quality improvements are possible but dependent on how the previous year's residue was managed. Yield reductions were small, and most importantly, farmers expressed more interest in these systems because of their labor and soil saving features.

7. Models and predictive methods addressing many agricultural aspects of sediment and related water quality problems were developed and applied. These included: a. a series of computer programs to predict watershed sediment yield using the USLE; b. an optimization model that predicts farm-level impacts of alternative sediment control policies; c. a hydrologic model for predicting watershed soil losses on an event basis; d. a multiple-regression model for predicting annual soluble phosphorus losses from cropped fields; and e. a methodology for predicting total phosphorus losses from confined livestock and winter-spread manure.

WATER QUALITY MONITORING NETWORK

A major objective of the Washington County Project was to establish a runoff and water quality monitoring network in Washington County. A detailed description of the monitoring program is given by Daniel et al. (2). This section describes: a. watershed selection criteria; b. land use and other watershed characteristics; c. station instrumentation; and d. methods used to evaluate runoff quantity and quality.

Watershed Selection

Criteria established for selecting agricultural and developing watershed study areas in Washington County (1) included:

> The physical characteristics of the watersheds, such as stream configuration, must lend themselves favorably to monitoring.
>
> The watersheds must show evidence of soil erosion or other sources of water pollution that can be attributed to topography, soil type and present or proposed land use activities.
>
> The agricultural watershed must reflect common agricultural practices used in the Great Lakes Basin.
>
> The developing watershed must be a medium to high density residential area under construction within the corporate boundaries of a village or city.
>
> Public support for the program must be demonstrated in the selected watersheds.

Following these criteria, agricultural study sites were selected in the Kewaskum Creek basin, and construction sites were chosen in Germantown (Fig. 1).

Description of Agricultural Sites in Kewaskum

The agricultural study sites lie in the Kewaskum Creek Watershed, comprising 7,940 acres (3,210 ha) of which about 40% is land devoted predominantly to dairy farming (Fig. 2). The dominant soils in this watershed are loams and silt loams in the Hochheim-Theresa association which covers almost 50% of Washington County. The U.S. Soil Conservation Service (SCS) designates these soils in land capability Class I and II, and Hydrologic Soil Group B, with only limited restrictions due to water and erosion hazards.

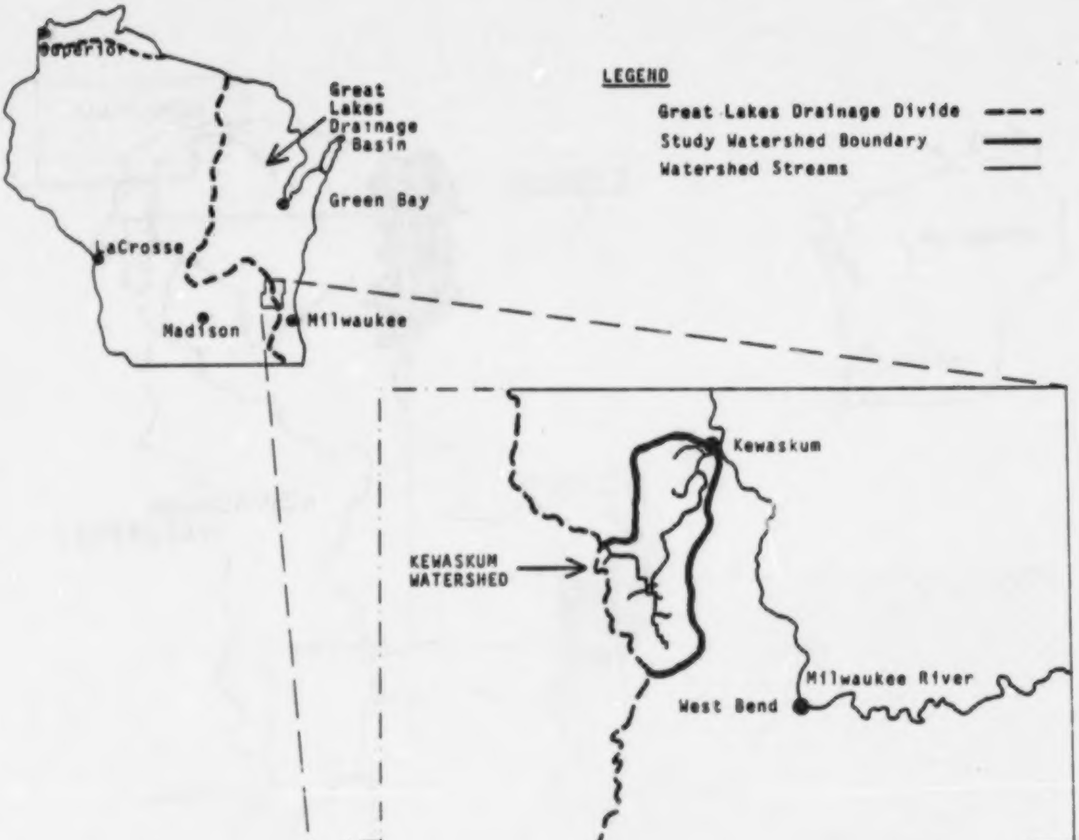
Superior
Great Lakes Drainage Basin
Green Bay
LaCrosse
Madison
Milwaukee
LEGEND
Great Lakes Drainage Divide
Study Watershed Boundary
Watershed Streams
Kewaskum
KEWASKUM WATERSHED
Milwaukee River
West Bend
GREAT LAKES DRAINAGE BASIN
Jackson
Menomonee River
GERMANTOWN WATERSHED

Fig. 1. Washington County, Wisconsin, showing its geographical location and selected project sites

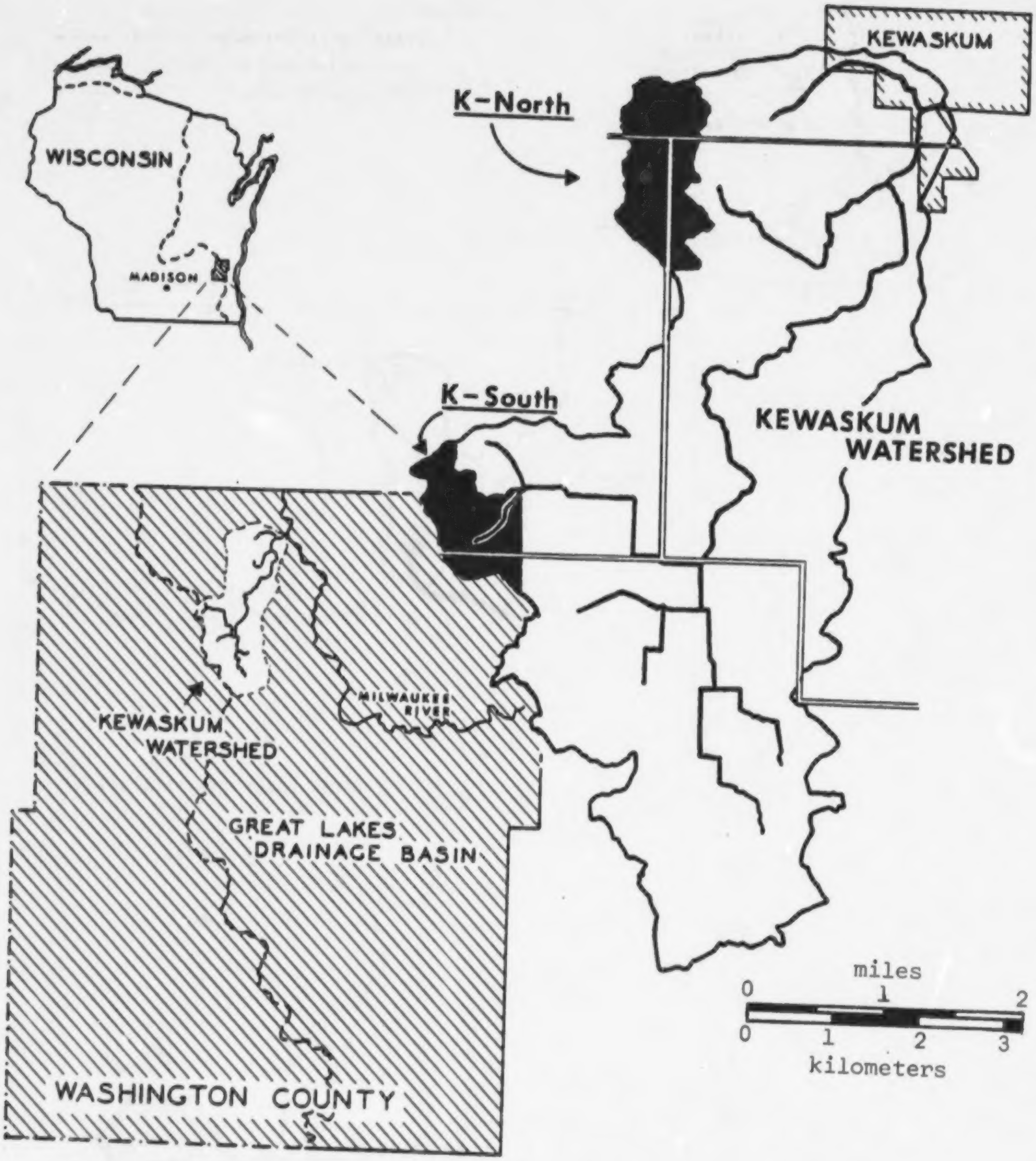
WISCONSIN
MADISON
KEWASKUM
K-North
K-South
KEWASKUM WATERSHED
KEWASKUM WATERSHED
MILWAUKEE RIVER
GREAT LAKES DRAINAGE BASIN
WASHINGTON COUNTY
miles
0
1
2
0
1
2
3
kilometers

Fig. 2. Location of Kewaskum Watershed within Washington County and location of K-North and K-South subwatersheds

These soils, from an agricultural standpoint, are potentially the most productive in the county. Lesser areas are occupied by soils in the Casco-Fox-Rodman association which are somewhat shallower and steeper and have critical management requirements. Finally, the organic soils of the Houghton-Palms-Adrian association make up a small, but hydrologically-important (Hydrologic Soil Group D) part of the watershed. Since extensive drainage is a necessary precursor to cropping, the predominant land use on these soils is either pasture or marshes and woodlands.

Monitoring stations were installed in two intensively farmed upland subwatersheds in the Kewaskum basin (Fig. 3). Although situated near each other, the North and South watersheds have very different topographic and land use features (Table 1). The North watershed is considerably steeper, and rotations are longer; most common are 5- to 7-yr rotations with 1 to 2 yr of corn. Contour strip-cropping is the most widely used conservation practice. In the South watershed, rotations are shorter and normally include 2 to 3 yr of corn. Many of the lower fields are tile-drained and the grass waterway is the most important conservation practice.

Stations K1 and K6 monitor nearly the entire North and South watersheds, respectively. Station K2 monitors a smaller portion of the North watershed that is mainly cropland but which also includes a barnyard and animal exercise area. Station K4 monitors a small, independent watershed adjacent to the basin of K1 and is influenced primarily by a barnyard and feedlot directly upslope. Station K5 monitors a predominantly cropland portion of the South watershed. Station K3 was abandoned early in the monitoring program due to equipment failures and poor site accessibility.

Both watersheds were intensively treated with conservation practices during the course of the project (Table 2). Most of the major practices were installed during 1977 and were operating by the 1978 monitoring season.

Description of Residential Construction Sites in Germantown

Monitoring stations were established in Germantown to obtain information on sediment and nutrient contributions to surface waters from construction activities. The Village of Germantown, on the periphery of the Milwaukee Metropolitan Area, is experiencing rapid development of large single and multiple family residential subdivisions, two of which were selected for monitoring. The locations of the monitored watersheds are shown in Fig. 4, and major land use features of each site are highlighted in Table 3. Watershed runoff was sampled in storm sewers which drained to intermittent or perennial streams below.

The developers of the Old Farm and Legend Acres subdivisions were cooperative in the project's efforts to monitor treated and untreated construction sites. In the Old Farm subdivision, the G2 watershed was to remain untreated while G3 was treated by applying a cover crop with mulch.

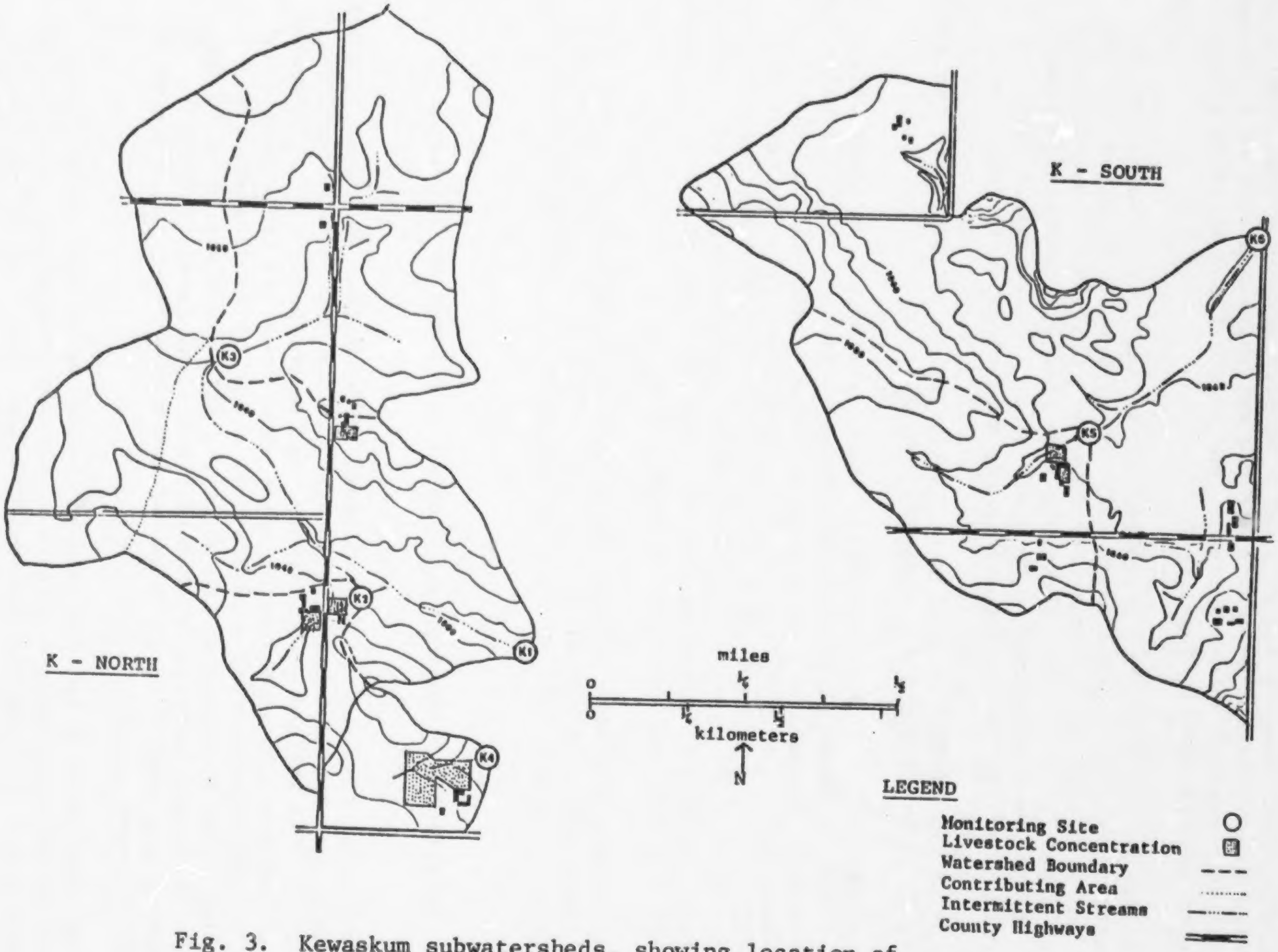
K - NORTH
K - SOUTH
K1
K2
K3
K4
K5
K6
1000
miles
0
¼
½
kilometers
N
LEGEND
Monitoring Site ○
Livestock Concentration ▨
Watershed Boundary
Contributing Area
Intermittent Streams
County Highways

Fig. 3. Kewaskum subwatersheds, showing location of monitoring sites and monitored watersheds

Table 1. Description of the Kewaskum agricultural watersheds

Characteristic	K NORTH						K SOUTH			
	K1 (includes K2 + K3)		K2		K4		K5		K6 (includes K5)	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Area (ha)	167		26.9		9.41		32.6		116	
Slope % > 7%	31		40		52		5		12	
Land use, %										
Corn	19	22	11	20	32	28	35	46	32	24
Oats	33	25	53	48	0	5	24	22	11	18
Hay	32	38	34	30	62	62	31	23	45	46
Pasture	9	9	0.7	0.7					1	1
Feedlots	0.44	0.44	0.56	0.56	6	6	1.2	1.2	1.5	1.5
Other	6	6	1	1			9	9	10	10
Conservation practices										
Strip-cropped and contour-strip-cropped, %	28	45	42	73	72	72				
Affected by grass waterways, %	0	18	0	18			0	51	14	54
Conservation tillage, %	0	2	0	12	0	21	0	0	0	2
Tiled, %							0	2	32	45
Surface drained, %										7
Feedlot protected					No	Yes				
Livestock inventory, au*										
Dairy cows (1.4 au/animal)	119				116.2				70	
Dairy heifers (0.8 ")	25.6				16				28	
Dairy calves (0.25 ")	1.25								10	
Beef calves (1.0 ")	1								60	
Beef feeders (0.8 ")					20					
Beef heifers (0.75 ")	15.75									
Sows & gilts (0.3 ")	8.4								1.8	
Boars (0.35 ")	0.7									
Market hogs (0.150 ")					18					
Laying hens (0.004 ")	0.6									
TOTAL	172.3				170.2				169.8	

*au = "animal unit," 1 au represents 1,000 lb (454.5 kg) of live weight animal equivalent.

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Table 2. Conservation practices in Kewaskum agricultural watersheds

A. Practices Installed

Practice:	Site K1[*] Before[***]	Added[+]	K2 Before	Added	K4 Before	Added	K5 Before	Added	K6[**] Before	Added	Total Before	Added
Contour Stripcropping, acres[++]	53	89	25	21	17						75	89
Stripcropping, acres	36		2								36	
Contouring, acres	2		2		3						5	
Conservation Tillage, acres		8				5				5		18
Grass Waterway, acres		5		2				2	1	6	1	11 (18,470 ft)
Surface Drainage, ft[+++]										700		700
Tiling, ft							360	6,250	25,230	17,050	25,230	17,050
Barnyard Control Structure						1						1
Other Barnyard Measures								1				1

B. Practice costs[‡]

Practice:	Total cost, $:
Contour Stripcropping	909
Conservation Tillage	1,540 - crop damage, fall plowing, excess seed and fertilizer
Grass Waterway	11,378 - initial construction 19,982 - repair, regrading, additional tiling, seed, fertilizer, labor, stone removal
Surface Drainage	860
Tiling	6,549
Barnyard Control Structure	19,170 - initial construction--concrete, diversion, tiling for downspouts 7,419 - related construction--tiling for downspouts, cattle crossing, gutters and downspouts
Other Barnyard Measures	3,195 - diversion, concrete diversion, gutters and downspouts, tiling for downspouts
Other Payments	1,173 - fall plowing, crop damage
TOTAL	72,155

C. Planning and assistance time & cost[‡‡]

	Time, (hr)	Cost, ($)
Planning	352	2,810
Technical Assistance	888	7,090
TOTAL	1,240	9,900

Notes:

[*] K1 includes K2
[**] K6 includes K5
[***] "Before" indicates practices present before project (pre-1976)
[+] "Added" indicates practices implemented through project (1976-1978)
[++] 1 ha = 2.47 acres
[+++] 1 m = 3.28 ft
[‡] "Costs" include payments to farmers and contractors (100% cost-share rate)
[‡‡] Includes time spent by Washington County SCS staff and [illegible] technician, cost figured at $7.98/hr

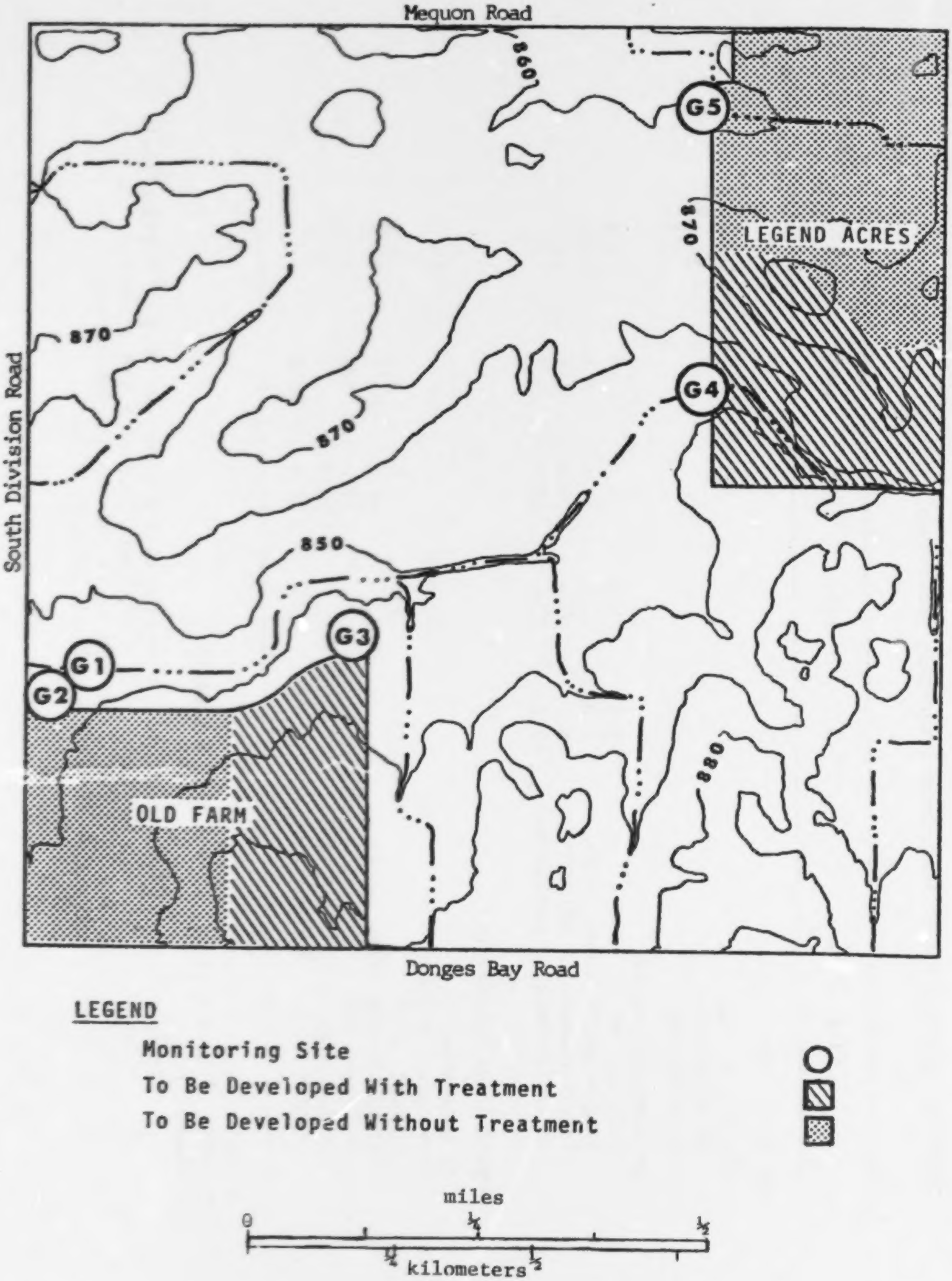
Mequon Road
South Division Road
Pilgrim Road
Donges Bay Road
860
870
870
870
870
850
880
G5
G4
G3
G1
G2
LEGEND ACRES
OLD FARM
LEGEND
Monitoring Site ○
To Be Developed With Treatment ▨
To Be Developed Without Treatment ▩
miles
0
¼
½
¼
kilometers
½

Fig. 4. Developing portions of Germantown showing monitoring sites associated with Old Farm and Legend Acres Subdivisions

Table 3. Description of Germantown urbanizing watersheds

Site	1975	1976	1977	1978	Total
Old Farm Subdivision					
Total area, ha					24.3
G2 watershed					14.5
G3 watershed					9.8
Development record					
Streets, ha*	3.9	3.9	3.9	3.9	3.9
Single family homes, units	2.0	57.0	50.0	9.0	118.0
Imperviousness, % added***	16.2	6.6	5.8	1.1	29.7
Imperviousness, % cumulative	16.2	22.8	28.6	29.7	
Legend Acres Subdivision					
G5 watershed, ha					16.7
Development record					
Streets, ha**	0	3.4	3.4	3.4	3.4
Single family homes, units			51.0	22.0	73.0
Duplexes, units			27.0	2.0	29.0
Imperviousness, % added***		20.5	13.5	4.2	38.2
Imperviousness, % cumulative	0	20.5	34.0	38.2	

* 2735 m, @ 14.6 m width

** 643 m, @ 18.3 m width; 1615 m @ 14.6 m width

*** Assumptions:

1. Single family houses are 158 m^2, driveways 74.3 m^2, garages 60.4 m^2 = 293 m^2/unit
2. Duplexes are 20.4 m^2, driveways 149 m^2, garages 92.9 m^2 = 446 m^2/unit
3. Single family home lots are .1 ha (1/4 acre) and are 32% impervious
4. Duplex lots are .13 ha (1/3 acre) and are 35% impervious

Similarly, Legend Acres, G5 and G1 represented untreated and treated developments, respectively. Due to technical problems encountered at G1, it was not possible to obtain data at this station, and it was eventually closed down.

Prior to disturbance, the major soil type in each watershed was Ozaukee silt loam. In a typical profile, the A-horizon (0 to 30 cm) consists of a slightly calcareous silt loam, and the B-horizon (30 to 70 cm) is slightly calcareous and undergoes a textural change from a silty clay loam to a silty clay (3). The substrate consists of a calcareous, silty clay loam, glacial till. The watershed's natural topography was gently sloping (<6%) and the upland soils were well-drained. Preparing the site for development involved clearing the total area of each watershed and stockpiling the topsoil. Leveling, grading and some redistribution of the topsoil followed, making all slopes <3%.

Site preparations for 118 single family housing lots in the Old Farm subdivision occurred during 1975. Two houses were built and occupied by the end of 1975. Extensive housing construction activity occurred during 1976 and 1977 with addition of 57 and 50 houses, respectively. Construction was completed on the remaining 9 lots during 1978. Although half of the lots were finished by the end of 1976, vegetation was not established until the end of 1977. Houses were constructed in both the G2 and G3 watersheds in a similar fashion.

Legend Acres, partially monitored by station G5, was platted for 131 lots zoned for single homes and duplexes. Site development occurred in 1975 and home construction began in 1976. By the end of 1977, 51 single family dwellings and 27 duplexes were completed and occupied; however, most of these lots were not stabilized with vegetation until the end of 1978. Twenty-two single family homes and two duplexes were completed during 1978. A portion of Legend Acres is zoned for multiple family apartments, and two apartment buildings were constructed adjacent to the G5 monitoring station during 1978. Site preparations for five additional apartment buildings, located in the northeast section of the watershed, were made in the fall of 1978.

A combination of limited precipitation and development pressure during 1976 resulted in construction proceeding rapidly. As a result, the mulch cover and seeding installed in the G3 watershed were completely disturbed before vegetation was established. Therefore, all watersheds were monitored as uncontrolled home construction sites.

Monitoring Equipment and Station Installation

General characteristics of each monitoring station are shown in Fig. 5. Equipment at each station consisted of a flow control structure, a flow recorder calibrated to determine the flow of water through the control structure, and an automated water sample unit powered by a 12-volt-lead acid automobile battery. A recording precipitation gauge also was installed at stations in each subwatershed. Individual station design specifications

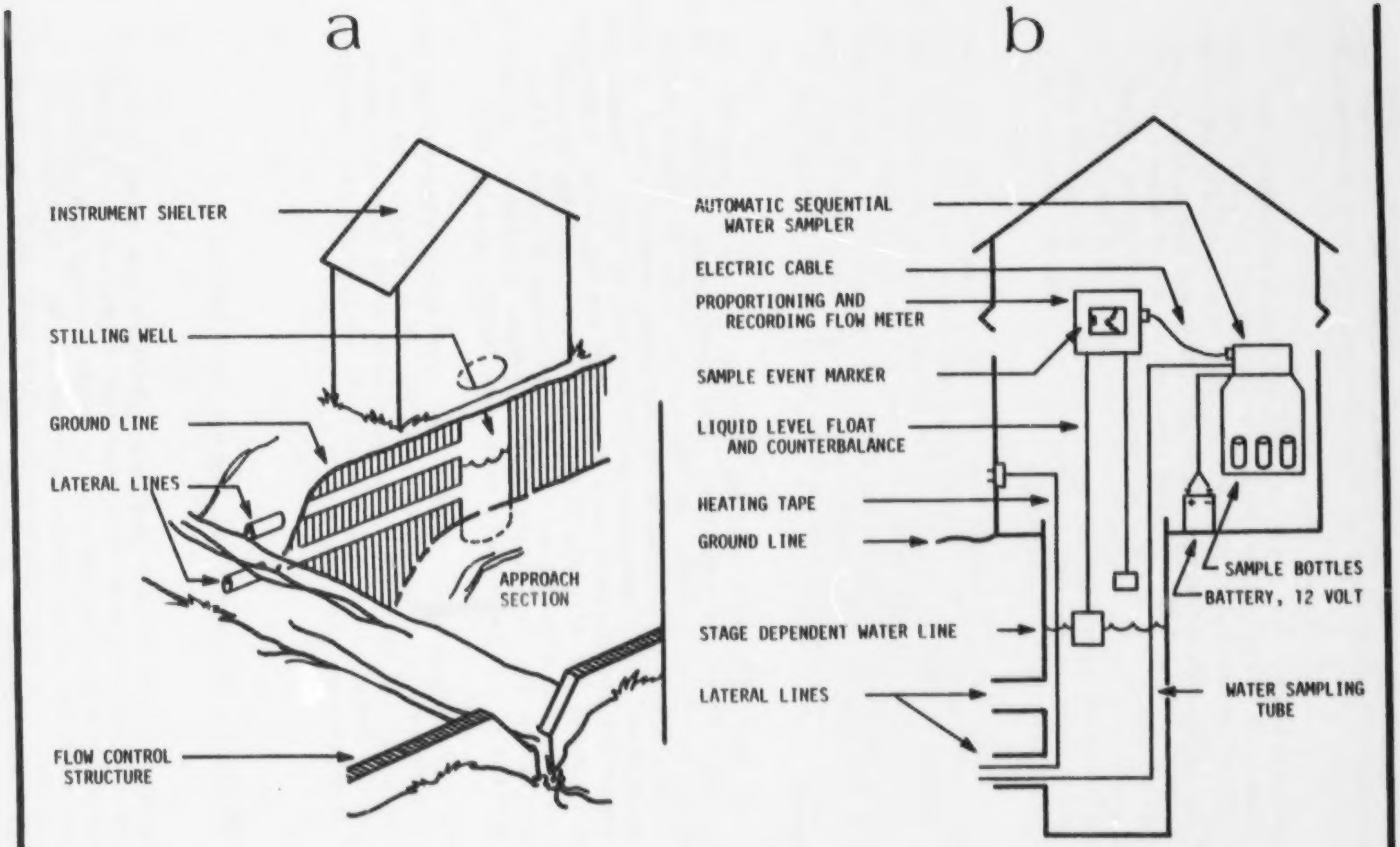
a
INSTRUMENT SHELTER
STILLING WELL
GROUND LINE
LATERAL LINES
APPROACH SECTION
FLOW CONTROL STRUCTURE
b
AUTOMATIC SEQUENTIAL WATER SAMPLER
ELECTRIC CABLE
PROPORTIONING AND RECORDING FLOW METER
SAMPLE EVENT MARKER
LIQUID LEVEL FLOAT AND COUNTERBALANCE
HEATING TAPE
GROUND LINE
STAGE DEPENDENT WATER LINE
LATERAL LINES
SAMPLE BOTTLES
BATTERY, 12 VOLT
WATER SAMPLING TUBE

Fig. 5. Diagram of a monitoring station exhibiting: a. basic physical components; and b. details of the instrumentation

are reported in the Washington County Project Annual Report for 1975 (4). A water flow totalizer displays cumulative runoff in a digital fashion. During runoff events, a mercury switch attached to the totalizer is tripped at a rate proportional to flow, thereby activating the water sampler. Samples were collected by pumping water from an intake manifold behind the flow control structure through tygon tubing into the sampler unit. The intake lines are purged before and after each sample to minimize cross contamination of samples. Due to the large number of samples triggered and the logistics involved, samples were collected, labeled, and frozen within a few hours after an event, and stored for later analysis. The monitoring stations were operable by late spring, 1976.

Table 4 lists the type of equipment and structures used in the project and the associated costs (2). Close engineering supervision was provided during installation as contractors were not familiar with these types of structures. Costs to install and maintain monitoring stations vary from region to region depending on materials and labor costs. Temporary structures could have been built more economically, but the more expensive permanent stations were chosen to assure acceptable performance over the study period and beyond.

Water Quality Sampling and Data Analysis

"Water quality" is measured in a variety of ways. The two most significant measures of water quality used in this study were:

1. The concentration of major parameters, e.g., suspended solids, total phosphorus, dissolved phosphorus, and nitrates, usually measured in mass/unit volume--mg/L or parts per million (ppm).
2. The watershed yield or load of these parameters, measured in mass rate of flow/unit time, e.g., kg/event or kg/yr.

The chemical concentrations in drainage water as it flows downstream affect directly all aquatic life. On a long-term basis, the watershed yield or load determines the amount of pollutants contributed to a lake or river downstream.

Water samples collected for the Washington County Project were analyzed either by the Wisconsin State Laboratory of Hygiene or the Soil Science Department of the University of Wisconsin-Madison. Before analysis, samples were thawed and a uniform portion of each sample for each event was composited. Each discrete sample as well as the composite sample was analyzed for the concentration of several water quality parameters (Table 5). Gravimetric procedures were used for determining total and suspended solids. Samples were also analyzed for various plant-nutrient fractions. Standard laboratory analysis procedures were used to determine concentrations of total phosphorus (P), soluble P, organic plus exchangeable nitrogen (N), ammonium-N, and nitrate plus nitrite-N (5). Dissolved molybdate-reactive P (DMRP) is the

Table 4. Installation costs of automated water quality monitoring stations

Item	Cost range*
Control structure**	
Weir***	$2500 - 3000
Flume[+]	
90 cm (3') H	250 - 300
120 cm (4') HL	650 - 750
60 cm (2') Parshall	650 - 750
Approach sections	
Weir[++]	500 - 1000
Flume[+++]	
90 cm (3') H	1500 - 2000
120 cm (4') HL	2000 - 2500
Leupold & Stevens 61R	1000 - 1200
ISCO 1680 automatic water sampler	1500 - 1800
Instrument shelters[†]	1200 - 1500
Recording rain gauge	500 - 700

*Cost will vary with geographic location.

**Includes installation cost.

***Concrete broadcrested weir (5:1)--varies with height.

+Flumes built locally.

++Cost includes grading, shaping and stabilization.

+++Cost of installing concrete.

†Includes cost of stilling well wood shelter (120 x 180 x 150 cm) with concrete floor.

Table 5. Water quality parameters evaluated

Frequency of analyses	Parameters		
	Unfiltered	Filtered	By difference
		Runoff samples*	
Routinely	Total solids Total N Total P	Dissolved solids** Ammonium-N Nitrate/Nitrite-N Dissolved molybdate-reactive P	Suspended solids Organic plus exchangeable-N Particulate P
Seasonally	Total organic carbon Chemical oxygen demand*** Total pesticides^{+} Total heavy metals^{++} Fecal coliform Fecal streptococcus	Alkalinity	
		Precipitation samples	
Seasonally	Total N Total P	Ammonium-N Nitrate/Nitrite-N Dissolved molybdate-reactive P	Organic plus exchangeable-N Particulate P

---

*Some routine and seasonal analyses were also made on tile discharges from the Kewaskum South Watershed.

**Total solids minus suspended solids.

***From stations monitoring drainage from livestock operations.

+Specific pesticide analyses were determined by the history of pesticide applications in the watersheds. watersheds.

++Pb, Cd, Cu, Hg, Zn, Cr, B.

operational definition of the soluble P fraction measured. The majority of this fraction is dissolved orthophosphate which is the P form most readily available to aquatic plants. Other parameters were analyzed in samples from particular stations.

Laboratory costs vary significantly depending on the type of analyses desired. If laboratory facilities are available for routine analysis, costs can be greatly reduced over commercial contracting. For this project, routine analysis costs were roughly $4/parameter or about $40/sample. Costs for chemicals, analysis, staff time, equipment, and overhead are included in these figures.

Loading rates for runoff events were computed from concentration and flow data. A parameter's load (yield) equals the total volume of flow multiplied by its flow-weighted mean concentration during the event. Flow-proportional sampling greatly facilitated data analysis, since weighting each discrete sample concentration to get an average storm value was not necessary. While event runoff volume was determined most accurately by analyzing the recorded hydrograph, the more readily obtained flow measurement provided by the totalizer mechanism on the flow recorder was often adequate. It was helpful to have both flow estimates for comparison.

In some instances, flow was recorded, but the water sampler either did not operate or did not collect enough samples during an event to provide an accurate estimate of mean event concentrations. In these cases, concentrations for the event were estimated with a technique developed by PLUARG (6) and applied by the Wisconsin Department of Natural Resources (7). Flow-weighted concentrations were derived for various flow ranges from available data for runoff events during the same season. These values were applied to the unsampled flows.

Data were adjusted to aid in comparing results from different watersheds and from different years. In order to adjust for differences in the size of the contributing area between monitoring sites, yields at each station were divided by the watershed area. Results were calculated as loads/unit area/unit time, e.g., kg/ha/yr. This is the standard form used for presenting annual pollutant loads from watersheds. One further manipulation--dividing by the annual "R" factor--roughly normalized the data by accounting for rainfall variability. The "R" factor is the rainfall erosivity factor derived by Wischmeier and Smith for the USLE (8). This division gave a "normalized load", in units of mass/unit area/unit R, e.g., hg/ha/R.

MONITORING RESULTS

Precipitation Variability

Natural variability in precipitation has a considerable impact on watershed response and therefore on measurements in a given year at a monitoring station. The impact of this natural variability had to be considered before the water quality changes due solely to land management alterations could be examined. Precipitation varied greatly during the study period in Washington County (Table 6). In 1976, total precipitation was about 20% below the 30-yr average for Washington County (75 cm). After May 16, 1976, there were no significant rainfall events for the rest of the year. Precipitation in 1977 was about 20% above normal, falling mainly during a few intense storms in late spring, summer and early fall. Precipitation in 1978 was below the 1977 amount but approximately equal to the area's 30-yr average; most of the intense storms occurred in late summer.

The R-factor shown in Table 6 was determined to estimate variations in the erosive potential of rainstorms between stations and years. Rainfall erosivity during the monitored years was compared to values in the past, as computed from records at the nearby weather station in Hartford, Wisconsin (Fig. 6). While 1976 was one of the lowest rainfall years, 1977 was one of the highest years on record for rainfall erosivity. Rainfall erosivity in 1978 was slightly above average. Most of the annual rainfall erosivity was contributed by a few intense storms. Furthermore, rainfall variations within the county in a year and even during the same event were considerable--on June 11, 1977, the rainfall at the K5 rain gauge had only 50% of the erosion potential of the rainfall recorded at K2, even though the rain gauges were < 2 miles (3.2 km) apart. The difference during this single event accounted for most of the difference between K2 and K5 in total "R" values for 1977. These observations highlight the importance of considering natural fluctuations in precipitation when explaining variations in water quality measurements.

Snowmelt and early spring rains on frozen ground have a high potential for causing excessive runoff and material yields, particularly in agricultural watersheds. The success of the Project in characterizing runoff during this period was limited. In 1976, runoff due to snowmelt and early spring rains was substantial. Unfortunately, the stations were not operable. In 1977, snow cover, and thus snowmelt, was minimal, but some early March rainfall events were sampled in Kewaskum and Germantown. In 1978, snow cover was significant, but the thaw occurred gradually and much of the meltwater was able to percolate into the ground or evaporate, thereby reducing snowmelt runoff. Freeze-up at the monitoring stations was also a problem so that when flow did occur it was not adequately measured, although some grab samples were collected. An early April rainfall event that was successfully monitored in Kewaskum in 1978 appeared indicative of frozen

Table 6. Precipitation data for Washington County, 1976-1978

Site	1976		1977			1978			30 yr. averages+	
	Total*	Snowfall**	Total	Snowfall	R***	Total	Snowfall	R	Total	Snowfall
	cm									
West Bend++	62.6	149	93.7	98	--	75.4	196	--	77.2	127
K2+++			72.6		261	65.3		211		
K5+++			67.2		178	57.7		180		
Germantown++	54.9	NA	89.0	89	--	70.3	141	--	72.5	113
G2+++			67.4		194	52.9		116		
G5+++			73.8		199	61.5		134		

* Total is the sum of rainfall and water equivalent of snowfall.

** Snow includes amount of snowfall during winter (includes Nov. and Dec. snowfalls from previous year).

*** Rainfall erosivity factor, calculated from 30-min rainfall records from project monitoring sites. This yields an R-factor approximately 15% greater than would be derived from hourly records. Mean R for county = 107 computed from 27 years of hourly records from Hartford, Wisconsin.

+ Computed from 1949 to 1978 U.S. weather station data.

++ U.S. weather stations, includes total precipitation for year.

+++ Washington County Project stations, includes only rainfall during monitoring season. 1977 includes March 3 to Nov. 1; 1978 includes April 6 to Oct. 15.

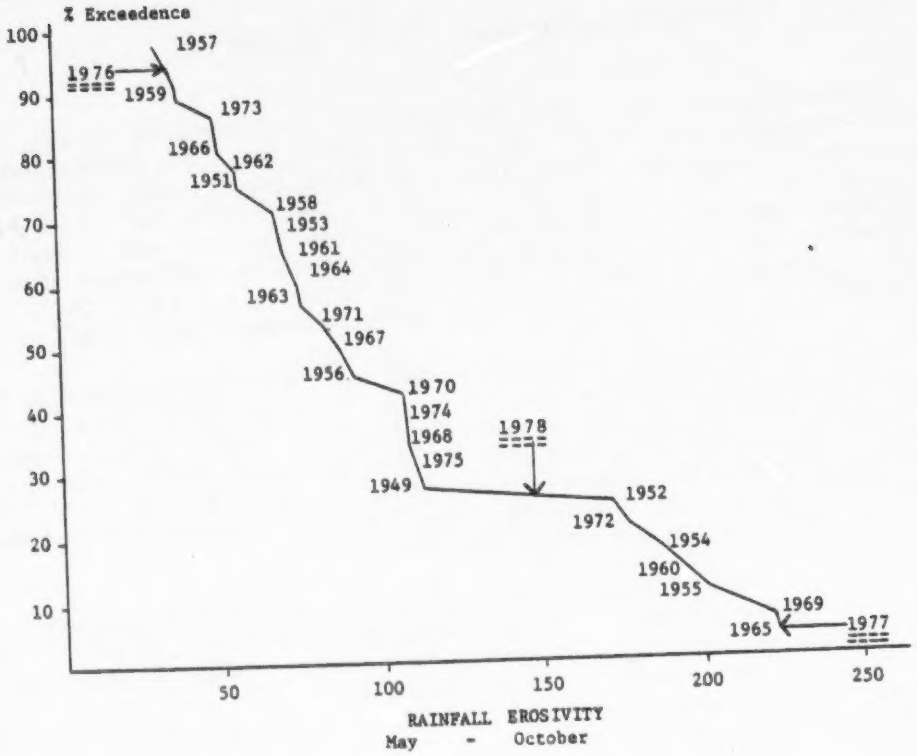

Fig. 6. Probability distribution of rainfall erosivity at Hartford, Wisconsin, May through October period, 1949 to 1978. Rainfall erosivity derived from hourly precipitation records by Wischmeier method (8). Exceedence: % of May to October period rainfall erosivity equal to or greater than the value shown.

or highly saturated ground conditions. The magnitude of the loads during the early spring events that were sampled shows the potential importance of this period. However, no attempt was made to estimate the quantity of runoff or material loads not sampled during early spring periods.

More success was realized sampling the major rainfall events that occurred from mid spring to late fall. Due to drought conditions during 1976, data are available only for 1977 and 1978.

Kewaskum Agricultural Watershed Results

As mentioned earlier, 1977 and 1978 data from Kewaskum roughly represent "before"-treatment and "after"-treatment conditions. The limitations of this analysis are recognized. Two years of data are insufficient to provide conclusive evidence that management changes are responsible for the differences in measured loadings. Furthermore, since practices were under construction during 1977, some of that year's data may reflect the influence of practice construction rather than the "before" conditions (e.g., K5 in 1977). Thus, only broad generalizations can be made about the results and trends indicated.

The basic monitoring results for 1977 and 1978 from Kewaskum are presented in Table 7; the results are given in cm or kg/ha units. Dividing by the applicable "R" factor produces "normalized loads", also presented in Table 7 in cm/R or g/ha/R units. Parameter concentration data were normalized by computing flow-weighted average concentrations for different time periods (Table 8). The major results--summarized below--are based on the normalized load and concentration data.

Water yield from surface runoff followed no consistent pattern. The greatest yield was measured from K2 during an early spring rainfall, probably due to frozen or saturated ground conditions. Relative water yields otherwise decreased substantially at K2 and K4 between 1977 and 1978, while the yield from K1 increased. Normalized water yield was generally higher from K-South than from K-North.

Sediment yields, however, were consistently and markedly lower in 1978 (see "suspended solids" in Table 7). Normalized yields decreased > 80% at K1 and K2. The highest sediment yield measured was at K5 during 1977. This was probably due to washouts of the grass waterways that were under construction. Unfortunately, problems with the monitoring equipment at K5 prevented the collection of enough comparative data from 1978. However, the sediment yield at K6 that year was down substantially--most of the waterways installed in K-South were finally seeded effectively by the end of 1978. In 1978, the order of relative watershed sediment yield was K4 > K6 > K2 > K1.

The sediment delivery ratio (SDR) accounts for the fact that not all of the soil particles detached and moved--as estimated by the USLE--actually reach a waterway and leave the watershed. The SDR is recognized as being important, but the processes controlling its magnitude and variability are poorly understood. Storm characteristics, watershed size, shape, drainage

Table 7. Runoff, sediment and chemical yields, and "normalized" yields for Kewaskum agricultural watersheds

							Yields													
Site	Rain		R*		Runoff		Suspended solids		Total phosphorus		Soluble phosphorus		Organic + Exchangeable nitrogen		Nitrate + nitrite nitrogen		Ammonium nitrogen		Chemical oxygen demand	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
	(cm)				(cm)		(kg/ha)													
K1**	70.4	60.5	260	200	1.32	2.02	367	50.2	0.414	0.125	0.027	0.044	1.18	0.451	0.078	0.121	0.023	0.030		
K2**	70.4	60.5	260	200	2.60	0.74	1,430	58.9	1.67	0.259	0.174	0.127	4.40	0.614	0.213	0.073	0.242	0.129		
K2***		65.3		211		5.64		195		1.15		0.521		3.02	4.07			1.74		
K4^{+}	72.6		261		4.71		5,590		19.6		2.51		30.1		0.336		2.65		2640	
K4**	70.4		260		4.05		5,550		18.9		2.42		29.8		0.245		2.48		2630	
K4^{++}		62.7		209		1.27		201		1.02		0.399		4.07		0.026		1.22		118
K5**	64.8		178		1.13		7,030		6.38		0.018		19.4		0.148		0.027			
K6**		55.4		179		2.22		93.4		0.346		0.167		0.806		0.937		0.396		
					"Normalized" Yields															
					(mm/R)		(g/ha/R)													
K1**					0.051	0.101	1,410	252	1.59	0.628	0.105	0.221	4.55	2.26	0.300	0.608	0.087	0.150		
K2**					0.100	0.037	5,480	295	6.40	1.30	0.667	0.637	16.9	3.08	0.817	0.365	0.930	0.649		
K2***						0.268		926		5.48		2.48		14.4		19.3		8.25		
K4^{+}					0.181		21,400		75.3		9.62		116		1.29		10.2		10.11	
K4**					0.156		21,300		72.7		9.31		114		0.944		9.55			
K4^{++}						0.61		960		4.87		1.91		19.5		0.123		5.82		0.57
K5**					0.064		39,500		35.9		0.102		109.2		0.831		0.149			
K6**						0.021		523		1.93		0.935		4.51		5.24		2.21		

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* Rainfall Erosivity Factor, calculated from 30-minute rainfall records during period monitored.
** March 8 to November 1, 1977 (excludes 3/4/77 storm); April 10 to October 15, 1978 (excludes 4/6 and 4/9/79 storms).
*** April 6 to October 15, 1978 (includes 4/6 and 4/9/78 storms).
+ March 4 to November 1, 1977 (includes 3/4/77 storm).
++ April 9 to October 15, 1978 (includes 4/9/78, excludes 4/6/78 storm).

Table 8. Concentration averages and ranges of water quality parameters for Kewaskum agricultural watersheds

Period site	Suspended solids		Total P		Soluble P		Organic and exchangeable-N		Nitrate and nitrite-N		Ammonium-N		Chemical oxygen demand	
	Mean	Range†††	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
	mg/L													
	Early spring, 77													
K1*	26	6-54	1.38	0.43- 1.98	1.05	0.29-1.6	3.96	2.0 - 8.5	1.31	1.03- 2.2	1.65	1.5 - 2.4		
K2**	40		4.3		3.1		8.4		2.1		13.0			
K4***			2.1	0.93- 3.07	1.39	0.74-1.83	5.46	0.58- 9.12	0.94	0.05- 3.85	1.76	0.22- 4.26	179	
K5***	340		0.46		0.08		2.65		1.13		0.29			
K6**	31		5.1		3.7		14.4		1.27		2.60			
	Late spring and summer, 77													
K1	3,454	134- 17,340	3.19	0.24- 12.4	0.20	0.03-0.74	9.09	1.2 - 34.0	0.61	0.03- 1.28	0.17	0.03- 0.61		
K2	5,823	245- 17,780	6.40	2.2 - 16.1	0.67	0.21-3.2	16.9	5.6 - 44.0	0.82	0.48- 1.8	0.93	0.24- 2.8		
K4			48.4	8.7 - 98.0	3.94	3.56-9.88	73.9	37.6 -134.0	0.61	0.01- 1.14	6.66	3.52-27.4	6,540	974-21,660
K5	66,190	18,310-348,480	57.1	16.7 -304.0	0.16	0.11-0.26	174.0	47.0 -1,015	1.30	0.19- 2.4	0.24	0.16- 0.47		
K6	4,600		6.8		0.07		21.0		0.55		0.19			
	Snowmelt, 78+													
K1	85		0.1		0.02		0.75		0.60		0.22			
K2	58.3		2.59		1.24		5.43		4.67		5.7			
K4	140	24.2-232	2.16	0.27- 5.0	1.08	0.12-2.84	5.32	1.02- 16.4	2.78	0.44- 6.31	3.86	0.44-11.8		
K5														
K6	82.5	5.0-224	3.11	0.31- 6.3	1.36	0.22-3.2	6.65	1.1 - 15.5	0.72	0.51- 1.02	5.32	0.30-13.0		
	Early spring, 78													
K1++	2,558		3.46		0.08		13.6		0.98		0.23			
K2+++	278	142- 1,465	1.83	0.62- 4.3	0.80	0.24-1.58	4.92	1.6 - 13.3	8.16	3.5 -18.8	3.29	0.47- 8.7		
K4	418	270- 773	9.82	7.96- 11.1	2.5	2.01-2.99	31.6	20.0 - 45.1	0.13	0.0 - 0.34	10.0	7.48-12.9	653	277- 874
K5														
K6†	240		3.75		2.4		7.0		0.87		19.0			
	Mid spring-summer, 78													
K1	248	10- 3,860	0.62	0.18- 2.5	0.22	0.03-0.88	2.23	1.2 - 8.2	0.60	0.06- 1.55	0.15	0.02- 1.2		
K2	798	85- 2,540	3.47	2.5 - 7.05	1.72	0.96-2.05	8.32	4.0 - 21.7	0.98	0.04- 1.84	1.75	0.44- 7.6		
K4	398	281- 558	7.98		3.13	2.01-4.7	32.0	15.7 - 47.9	0.20	0.05- 0.34	9.58	6.93-20.4	928	398- 1,070
K5††	1,635	490- 2,905	2.84	1.26- 3.75	0.61	0.52-0.77	7.37	3.3 - 10.4	0.44	0.41- 0.49	0.44	0.09- 0.64		
K6	424	115- 3,085	1.57	0.75- 5.4	0.76	0.34-3.0	3.64	1.7- 15.2	4.23	0.36-35.0	1.79	0.29-16.0		

*includes 2/23/77, 3/4/77
**includes 2/23/77
***includes 3/4/77
+includes 3/23-31/78
++includes 4/9/78
+++includes 4/6-9/78
†includes 4/6/78
††includes 8/18/78
†††Ranges not given if only 1 value available

pattern, soil type, land use and conservation practices all influence the SDR.

Sediment delivery ratios were calcualted for the monitored watersheds in Kewaskum (Table 9). Except for K4 and K5 in 1977, the SDRs were quite low, i.e., < 5% from all monitored watersheds. The highest SDR--86%--was measured at K5 in 1977. This is misleading, however, since the soil loss predicted by the USLE does not include gully erosion, which was substantial in the grass waterways under construction in K5. At all sites, predicted soil loss and the SDR were much lower in 1978 than in 1977. This could be due in part to variations in storm characteristics and to the installation of conservation practices. Some interesting comparisions can be made between SDR values from different watersheds for the same years: In 1977 the SDR at K2 was about twice that at K1, which was expected since the K2 watershed is only 33% the size of the K1 watershed. In 1978, however, the SDR values at K1 and K2 were about the same. Perhaps once upland soil conservation practices (e.g., strip-cropping) were completed, no additional sediment reductions within drainageways occurred. Furthermore, it was found that the SDR at K6 in 1978 was much greater than that at K1 or K2, although the South watershed had flatter slopes than the North watershed. This could indicate that grass waterways (the main practices installed in the South watershed) are not substitutes for upland erosion control practices for arresting watershed sediment loss. Except for K5 in 1977, the SDR at K4 was the greatest of all sites for both years. This watershed was the smallest, steepest and most influenced by a barnyard and feedlot. By 1978 animals were generally confined to the smaller, paved feedlot that was installed and the original exercise area was seeded down. Animals also spent a small portion of time during 1978 in a new exercise area established outside of the monitored watershed. The SDR reduction between 1977 and 1978 at K4 was over 90%, the most substantial drop of all the agricultural sites monitored.

Phosphorus (P) and nitrogen (N) are generally the most important nutrients in runoff. Total P and N closely followed sediment patterns because most of these nutrients were transported attached to soil particles. Decreases from 1977 to 1978 were greatest at K4, where the reductions in relative yields of total P and N were 94% and 83%, respectively. Reductions of P and N at K1 ranged from 50% to 60%; reductions at K2 were greater than 80% between 1977 and 1978. The soluable nutrient fractions exhibited more variability. In general, the dissolved portion of the total load increased at each site between 1977 and 1978--soluble P rose from 5 to 10% of total P, to 35 to 50%. The portion of dissolved N forms increased from about 10% to 25% in the North watershed, and to over 60% of the total N in K-South. The relative soluble P load decreased significantly (by 84%) at K4, while increases occurred at K1 (61%) and K2. The increase at K2 in 1978 was due almost entirely to high yields during an early April event. Dissolved soluble N yields (normalized) compared closely with the dissolved P results. (Nitrate + nitrite)-N was the dominant form of dissolved N at K1 and K6, while soluble ammonium-N was higher at K4. Nitrate-N was higher at K4 during the early spring events, while ammonium-N was more important at other times. Nutrient changes in the South watershed were not adequately

Table 9: Kewaskum monitoring results, sediment delivery ratios

Site	Predicted soil loss*		Measured watershed yield**		Sediment delivery ratio***	
	1977	1978	1977	1978	1977	1978
	kg/ha				%	
K1	15,126	7,353	367	50.2	2.43	0.68
K2	30,171	11,824	1,426	58.9	4.73	0.50
K4	17,741	8,289	5,594	201	31.53	2.42
K5	7,703		6,626		86.02	
K6		4,656		91		1.95

* Predicted by USLE, corrected for actual "R" factor that year.

** From monitoring stations, rainfall events only.

*** Delivery ratio = $\frac{\text{(measured)}}{\text{(predicted)}} \times 100$.

determined, but results in 1978 indicate higher normalized yields of all nutrient fractions from K6 than from either K1 or K2. (Nitrate + nitrite)-N yields, in particular, were much higher at K6. By 1978 nearly 50% of the South watershed was affected by tile drainage. Grab samples from the tile lines were analyzed perodically and showed (nitrate + nitrite)-N concentrations quite similar to those measured at K6. Although the principal tile system discharges were below the K6 station, surface leaks from the tile system into the waterway above K6 could be responsible for the high nitrate/nitrite values measured at this station.

The concentration data parallels loading estimates (Table 8). Levels of suspended solids and related nutrients were much lower in 1978, while concentrations of soluble substances remained the same or increased. Soluble concentrations were generally highest in samples of snowmelt and early spring rainfall events. Suspended solids levels were lowest during snowmelt but were sometimes quite high in early spring runoff (e.g., K1 on 4/9/78). In general, soluble concentrations appear inversely related to suspended solids levels. For instance, when suspended solids were high at K5 in 1977, dissolved nutrient levels were relatively low. Concentrations of most parameters were highest in runoff from K4, the barnyard site, even after treatment. Before treatment (1977), chemical oxygen demand (COD) levels in K4 runoff average over 6000 mg/L, i.e., considerably more than is found in raw domestic sewage. Soluble (nitrate + nitrite)-N concentrations were highest at K6 during summer storm runoff.

Germantown Construction Site Results

Large scale residential construction has long been considered a major contributor of sediment to surface waters (9), but little quantitative data has been collected. This is especially true of the home construction phase after the development is laid out. To help fill this gap, information was obtained from subdivisions under construction in Germantown. Details of materials and procedures for monitoring and results for 1977 were given by Daniel et al. (10).

At the Germantown G2 and G3 sites (Old Farm), essentially all the land was under intensive home construction during 1977 and stabilizing by 1978. Building at Legend Acres (G5) went on during 1977 and 1978. Basic monitoring results from 1977 and 1978 are presented in Table 10. Total loads, in cm and kg/ha are given in Table 10A. These values were normalized by the R-factor to account for storm variations between watersheds and the year of measurement (Table 10B). Averages and ranges of parameter concentrations are presented in Table 11.

Normalized water yields were 5 to 10 times greater than those from the agricultural watersheds. Water yields remained constant at G3 and increased at G2 and G5 between 1977 and 1978. Runoff remained relatively high because impervious surfaces--rooftops, driveways and streets--did not permit rainwater to infiltrate and provided for rapid transport of runoff to the storm sewers.

Table 10. Runoff, sediment and chemical yields, and "normalized" yields for Germantown urbanizing watersheds

Site	Rain		R*		Runoff		Suspended solids		Total phosphorus		Soluble phosphorus		Organic + exchangeable nitrogen		Nitrate + nitrite-nitrogen		Ammonium nitrogen	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
									Yields									
	— (cm) —				— (cm) —		(kg/ha)											
G2**	67.4	52.9	194	116	17.9	25.1	36,300	2,750	29.0	2.36	0.138	0.290	75.7	5.69	2.32	2.43	0.599	0.305
G3***	67.4	52.9	194	116	22.4	13.5	19,300	4,650	11.4	2.76	0.143	0.389	16.2	7.24	2.78	1.21	0.397	1.76^{+}
G5**	73.8	61.5	199	134	14.5	16.4	15,900	18,700	10.2	8.43	0.099	0.110	16.2	15.9	1.47	0.84	0.191	0.416
									"Normalized" Yields									
					— (mm/R) —		(g/ha/R)											
G2*					.923	2.16	187,000	23,700	149	20.3	0.71	2.50	390	49.1	12.0	21.0	2.88	2.63
G3***					1.15	1.16	99,500	40,100	58.6	23.8	0.74	3.35	83.3	62.4	14.3	10.4	2.05	15.1^{+}
G5**					.782	1.22	79,800	139,000	51.5	62.9	0.50	0.82	81.2	119	7.39	6.27	0.96	3.11

Notes:

* Rainfall erosivity factor, calculated from 30-minute rainfall intensities for periods monitored
** March 28 to November 1, 1977; May 15 to October 5, 1978
*** March 3 to November 1, 1977; April 23 to October 5, 1978
+ Includes one event with extremely high concentrations

Table 11. Concentration averages and ranges of water quality parameters for urbanizing watersheds in Germantown

Site	Suspended solids		Total phosphorus		Soluble phosphorus		Organic + exchangeable nitrogen		Nitrate + nitrite-N		Ammonium nitrogen	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
	mg/L											
							Spring, 1977*					
G2	5,471	292 - 20,750	3.61	0.15 - 13.6	0.12	0.01 - 0.2	5.79	1.2 - 18.9	4.89	2.2 - 11.5	0.14	0.04 - 0.29
G3	2,378	202 - 11,680	1.86	0.14 - 6.24	0.03	0.01 - 0.2	3.6	0.6 - 9.7	2.19	0.52 - 3.9	0.11	0.02 - 0.33
G5	3,435	184 - 5,188	2.54	0.22 - 3.86	0.15	0.01 - 0.2	4.17	0.9 - 6.7	4.16	2.0 - 5.0	0.11	0.03 - 0.17
							Summer, 1977**					
G2	23,563	2,300 - 76,540	18.99	2.25 -103	0.07	0.02 - 0.22	49.6	5.6 -310	0.68	0.14 - 5.2	0.29	0.03 - 0.81
G3	11,787	1,162 - 38,250	6.73	0.83 - 35.20	0.06	0.02 - 0.27	8.5	2.3 - 44.8	0.77	0.18 - 3.2	0.16	0.02 - 0.81
G5	12,729	2,944 - 36,800	8.29	2.60 - 34.80	0.05	0.02 - 0.10	12.6	1.8 - 62.0	0.58	0.28 - 1.2	0.10	0.02 - 0.24
							Fall, 1977***					
G2	6,908	4,220 - 22,495	4.8	3.45 - 7.85	0.08	0.06 - 0.18	18.6	0.8 - 34.0	2.3	1.47 - 3.8	0.79	0.21 - 1.1
G3	5,542	1,225 - 22,960	3.3	1.16 - 12.7	0.21	0.02 - 0.20	7.9	2.9 - 60.0	1.42	0.42 - 3.7	0.43	0.14 - 3.8
G5	4,713	1,125 - 8,380	2.1	0.79 - 3.24	0.10	0.03 - 0.19	6.5	2.2 - 13.9	1.05	0.7 - 1.37	0.41	0.09 - 1.1
							Spring, 1978*					
G2	1,631	520 - 8,530	0.97	0.43 - 3.06	0.15	0.02 - 0.95	2.7	1.7 - 5.5	1.5	0.71 - 5.2	0.14	0.04 - 1.47
G3	2,429	895 - 4,550	1.76	0.69 - 2.38	0.11	0.06 - 0.22	4.0	1.5 - 6.3	0.9	0.76 - 1.6	0.5	0.27 - 0.70
G5	NS		NS		NS		NS		NS		NS	
							Summer, 1978**					
G2	1,097	158 - 6,445	0.94	0.32 - 4.1	0.12	0.02 - 0.18	2.4	1.2 - 10.0	0.98	0.16 - 3.24	0.12	0.02 - 0.46
G3	3,446	115 - 13,080	2.05	0.74 - 3.85	0.15	0.02 - 0.22	7.5	2.0 - 11.0	0.89	0.37 - 1.6	0.33+	0.20 - 0.21
G5	11,371	930 30,900	5.14	0.92 - 15.2	0.07	0.03 - 0.13	9.7	1.8 - 30.7	0.51	0.06 - 1.61	0.25	0.07 - 0.61

*Snowmelt to May 31

**June 1 to September 30

***After September 30

+Average concentration calculated without one event with large concentrations; average including it was 1.9

NS No Sampling

Sediment yields in 1977 from the urbanizing watersheds ranged from 15,900 to 36,300 kg/ha (see "suspended solids" in Table 10). Normalized sediment loads were about 10 times greater than those from the agricultural watersheds. During site development all surface vegetation was removed and the topsoil stripped and stockpiled. The sediment problem in Germantown was further magnified during the construction of individual homes by uncontrolled access to lots by trucks and heavy equipment, thereby tracking soil back onto the streets. Large amounts of excavated soil were also left on or near the streets, further increasing the chances for sediment to be transported to the storm sewer system. Water pumped from flooded foundations also contributed to sediment loads from the construction sites.

Substantial decreases in sediment yields were evident at the G2 and G3 sites in 1978 compared to 1977, while yields at G5 increased slightly because construction continued. At G2 and G3 lawns were being established which caused sediment yields to be lower, although they were still much greater than yields from the agricultural sites. Similar sediment yields, measured from nearby residential areas by the Menomonee River Pilot Watershed Study, ranged from 800 to 2300 kg/ha/yr (11). The higher value was obtained from a watershed undergoing housing construction.

Total phosphorus (P) and nitrogen (N) loads closely paralleled sediment losses. Sediment-attached fractions accounted for > 90% of total N and total P loads at all sites in 1977 and at G5 in 1978, and 85% of the P loads and 70% of the N loads at G2 and G3 in 1978. In 1977, normalized P and N loads were exceeded only by the barnyard site losses (K4). Of the Germantown sites, the G2 watershed produced the highest loads of total P and organic plus exchangeable N during 1977. Dissolved loads were similar to loads from the agricultural sites.

Nutrients associated with soil particles, and thus total loads, decreased substantially between 1977 and 1978. Soluble P losses remained about the same at G5 and approximately doubled at G2 and G3. Ammonium (soluble) increased significantly at G3 because of one event on September 11-13, 1978. Ammonium doubled at G5 and decreased at G2 between 1977 and 1978. Nitrate plus nitrite increased slightly at G2 and decreased at G5. These differences may be due in part to the relative proximity of lawn fertilizers to the monitoring stations. Total nutrient yield reductions were greatest at G2. During 1978, when the land surfaces were generally more stablized, less variability in nutrient yields occurred than during 1977.

Variations in the concentrations closely followed the loading changes between 1977 and 1978 (Table 11). In 1977 high concentrations of sediment and associated parameters occurred at the beginning of events showing a "first flush" effect (Fig. 7). Concentrations of suspended solids ranged from a few hundred mg/l to 75,000 mg/L; however, average concentrations were from 2500 to 7000 mg/L in the spring and fall and from 12,000 to 25,000 mg/L in the summer, when construction activity was most intense. During 1978, G5 showed concentrations of sediment, P and N similar to those observed in 1977. Substantially lower values were observed at G2 and G3 in 1978--suspended solids concentrations ranged from 100 to 13,000 mg/L and averaged

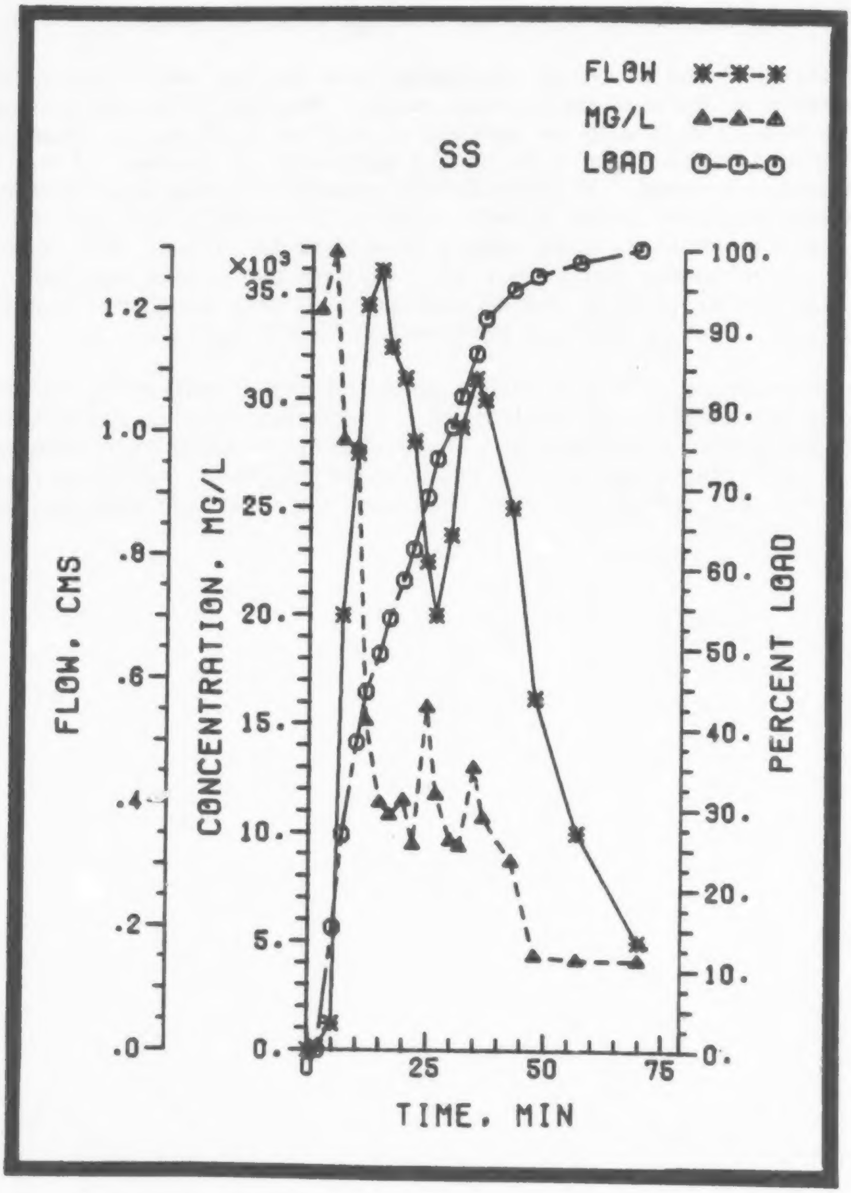


Fig. 7. Pollutograph showing "first flush" effect on suspended solids (SS) concentrations (mg/L) at Station G5, June 11, 1977

from 1000 to 3500 mg/L. Total phosphorus and nitrogen concentrations at G2 and G3 paralleled those of sediment. In 1977, P ranged from 0.15 to 35 mg/L with an average of 2 to 5 mg/L in the spring and fall and from 6 to 9 mg/L in the summer; N levels ranged from 0.5 to 310 mg/L with an average between 3.6 and 50 mg/L. In 1978 the range in P concentrations narrowed to 0.3 to 4 mg/L and the average dropped to 1 to 2 mg/L. The range of N became 1 to 11 mg/L, the average dropping from 2 to 7 mg/L.

Dissolved P and ammonium concentrations did not vary significantly during events or between monitoring years. The DMR-P concentrations ranged from 0.01 to 0.25 mg/L with an average of 0.07 to 0.15 mg/L. Ammonium concentrations varied from 0.02 to 1.1 mg/L with an average of 0.1 to 0.5 mg/L most commonly observed. Nitrate/nitrite concentrations were inversely proportional to flow during runoff events. More variation was observed in 1977, where concentrations ranged from 0.15 to 11 mg/L with an average of 0.5 mg/L in the summer and from 1 to 5 mg/L in the spring and fall. In 1978 (nitrate + nitrite)-N concentrations were more constant, ranging from 0.1 to 5 mg/L, with an average of from 0.5 to 1.5 mg/L.

We must stress that the extent to which these monitoring results can be applied and interpreted is limited. Two years of data are not enough to yield documented conclusions. Where similar results were obtained at more than one site, these may be given added credence. It is recognized, however, that all inferences from this data must be made with caution.

OPERATIONAL PROBLEMS AND ALTERNATIVES OF THE MONITORING SYSTEM

In this section, improved data collection and analytical techniques and methods of costs reduction are described. Conclusions are as follows:

1. Sample intake position in the flow control structure significantly influences the measured concentrations of water quality parameters. During high flow events samples collected by a floating intake had lower concentrations of some parameters than did samples collected at the bottom of the control structure.

2. When all samples collected during a runoff event are carefully composited into one sample, accurate estimates of parameter loads can be obtained from analysis of only the composited sample. Compositing provides a less costly but reliable means of analysis.

3. Special, time-consuming procedures were necessary in order to successfully sample snowmelt and spring runoff.

Concentration Variations Due to Sampler Intake Location

During the first sampling season, sample intake strainers were attached near the floor of the flow control structure approach sections at all monitoring stations (12). It was assumed that mixing action within the self-flushing control structures would insure sample concentrations that were representative of the actual amounts transported from the watersheds. However, after analyzing data from the 1977 monitoring season, it appeared that during some runoff events there was insufficient mixing action.

To determine the effect sample intake location had on parameter concentration and on calculated loads, two automatic water samplers were installed at the G5 monitoring station. The water samplers were adjusted to be activated simultaneously during runoff events in 1978. One intake was attached to the floor of the flow control structure approach section (Method 1), while the second intake was attached to a float-pivot arm assembly (Method 2) and adjusted so that samples were withdrawn at the mid-level of water within the flow control structure (Fig. 8). Discrete samples were analyzed separately to compare differences in concentrations of solids and phosphorus and nitrogen parameters for the two sampling methods. Event loads of the parameters also were used as a basis of comparison.

Three runoff events were effectively double-sampled in this manner during the 1978 monitoring season. Nine, two, and eight pairs of water samples were obtained from these three events. A comparison of parameter concentrations for each sample pair (Methods 1 and 2) per runoff event indicated three trends. First, concentrations of suspended solids, organic

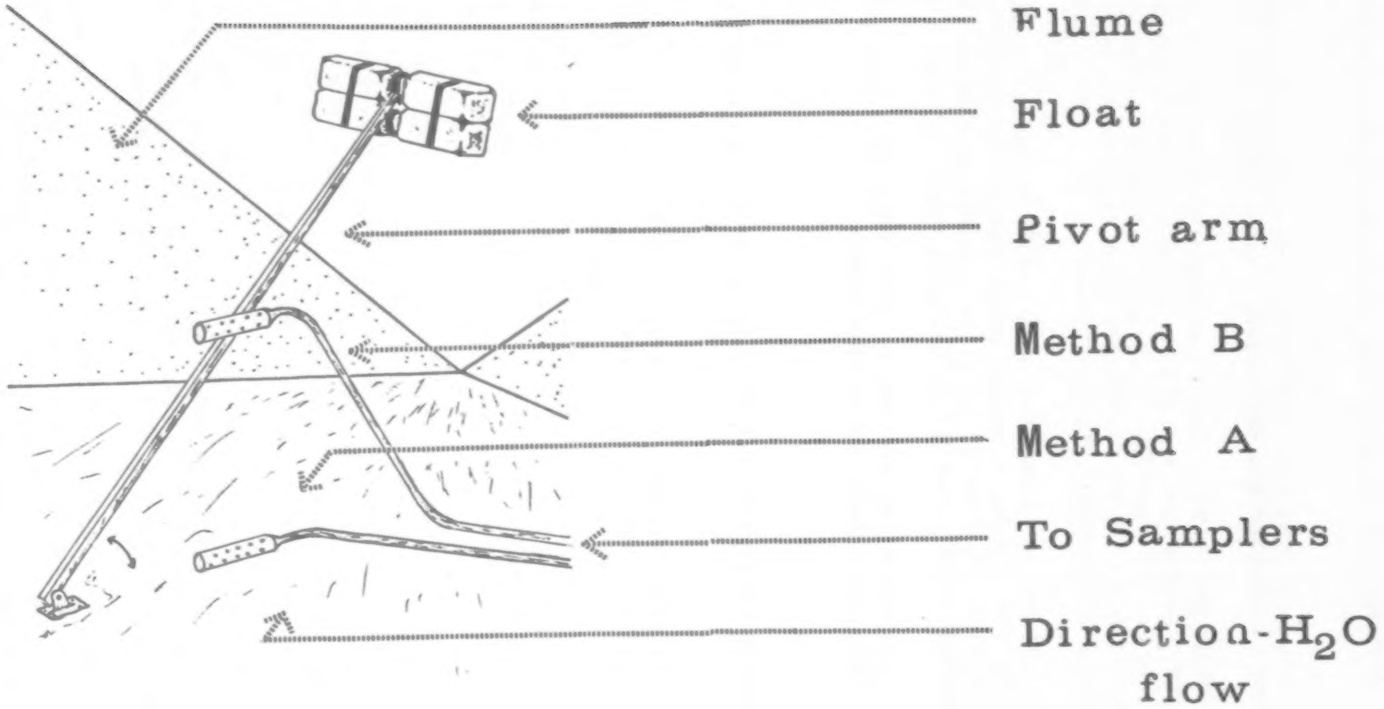

Flume
Float
Pivot arm
Method B
Method A
To Samplers
Direction-H_2O flow

Fig. 8. Diagram of monitoring site, depicting two alternative positions: Method A, intake on the floor of approach section; Method B, intake on pivot arm and samples taken at midstage (12).

plus exchangeable nitrogen, and total P were consistently higher throughout each runoff event when the sampler was stationary on the floor of the approach section (Method 1). Second, the concentrations of dissolved P and ammonium-N for the paired samples were similar for each runoff event. Third, the concentrations of (nitrate + nitrite)-N were consistently higher throughout each runoff event with the float-controlled sampler intake (Method 2). Consistently higher suspended solids and sediment-associated parameter concentrations were obtained using Method 1 indicating that mixing action in the approach section and the flow control structure--even at peak discharge rates--was not sufficient to cause uniform vertical concentrations within the water column. With midstage sampling, loads of suspended solids, total P, and (organic + exchangeable)-N for the three runoff events tested, were 44, 39, and 35% lower, respectively, than loads determined with the stationary sampler. Concentrations of dissolved P and ammonium-N did not vary much with the position of the sampler intake. However, (nitrate + nitrite)-N concentrations were unexplainably higher with midstage sampling.

A statistical analysis of the data indicated a straight line correlation between the particulate fraction total loads derived from Methods 1 and 2. Further study, however, is necessary to better define the relationship between parameter concentrations and the vertical position of sampling to determine how best to adjust load measurements to account for these differences.

All sampler intakes were placed on floating devices (Method 2) in 1978. Because of this, some of the changes in sediment and sediment-associated parameter loads between 1977 and 1978 at some of the sites may be attributable to this change.

Composite and Discrete Sampling

The technical feasibility of using a flow proportional composite sample and a three-sample mean for determining event loads was evaluated (13). Runoff data from sites in Kewaskum and Germantown were used in comparing different methods of calculating event loads. For the same event, loads were calculated using the following methods: 1. Discrete event load (DEL), 2. composite event load (CEL), and 3. three-sample mean event load (SMEL) (Fig. 9). The DEL method is based on standard integration techniques using the concentration of individual discrete samples taken at preselected runoff intervals. The CEL procedure utilizes the concentration of a flow proportional composite in combination with total volume of runoff, whereas the SMEL method uses the mean concentration of three selected temporal samples. The DEL data are assumed to be true values and serve as the basis of comparison for the CEL and SMEL procedures.

Figure 10 illustrates graphically that a highly significant correlation existed between the DEL and the CEL and SMEL methods for estimating event loads of contaminants. The CEL and SMEL methods were found to provide adequate predictions of the actual (DEL method) event loads. Both methods predicted dissolved water quality parameters [DMRP, ammonium-N and (nitrate + nitrite)-N] more accurately than sediment-associated parameters (suspended solids, organic plus exchangeable nitrogen, total P); mean predicted loads

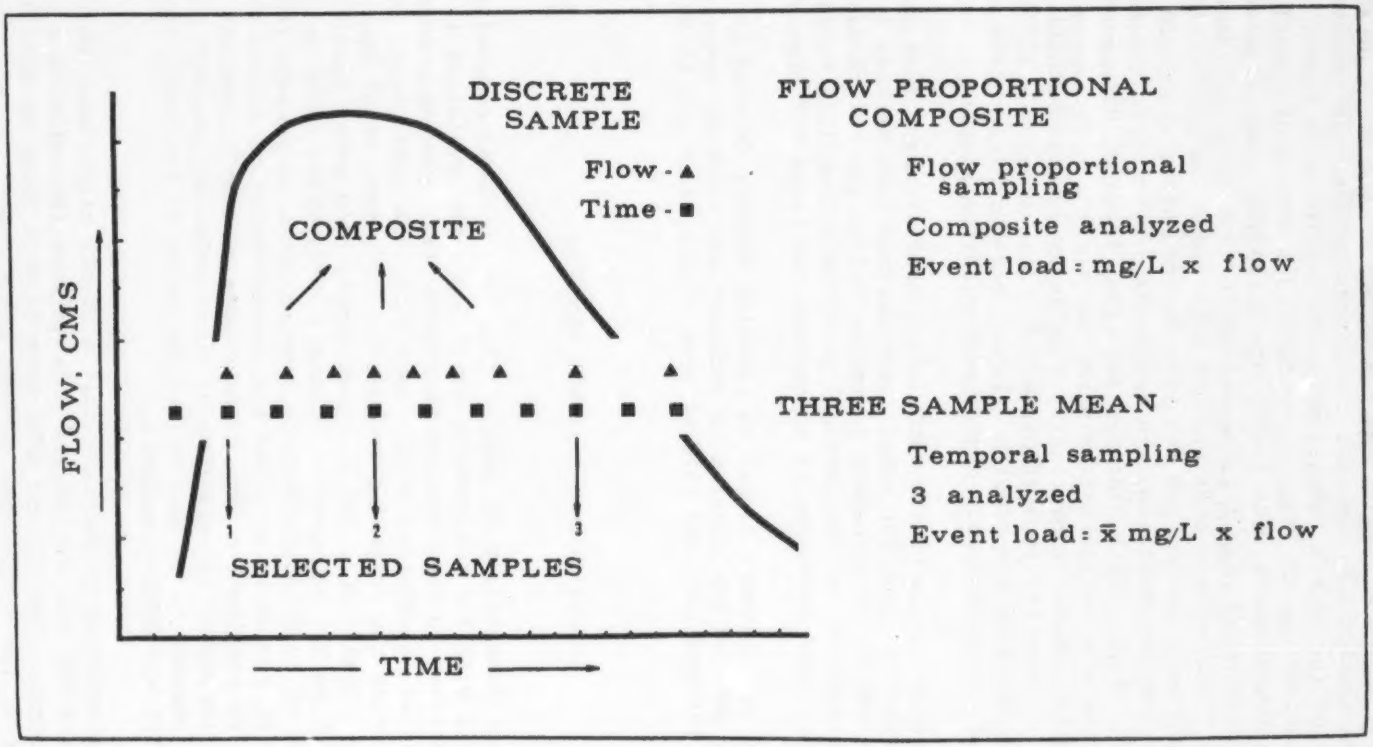

DISCRETE SAMPLE
Flow - ▲
Time - ■
COMPOSITE
FLOW, CMS
1
2
3
SELECTED SAMPLES
TIME
FLOW PROPORTIONAL COMPOSITE
Flow proportional sampling
Composite analyzed
Event load = mg/L x flow
THREE SAMPLE MEAN
Temporal sampling
3 analyzed
Event load = x̄ mg/L x flow

Fig. 9. Typical hydrograph depicting different methods of sampling and calculating event loads (13).

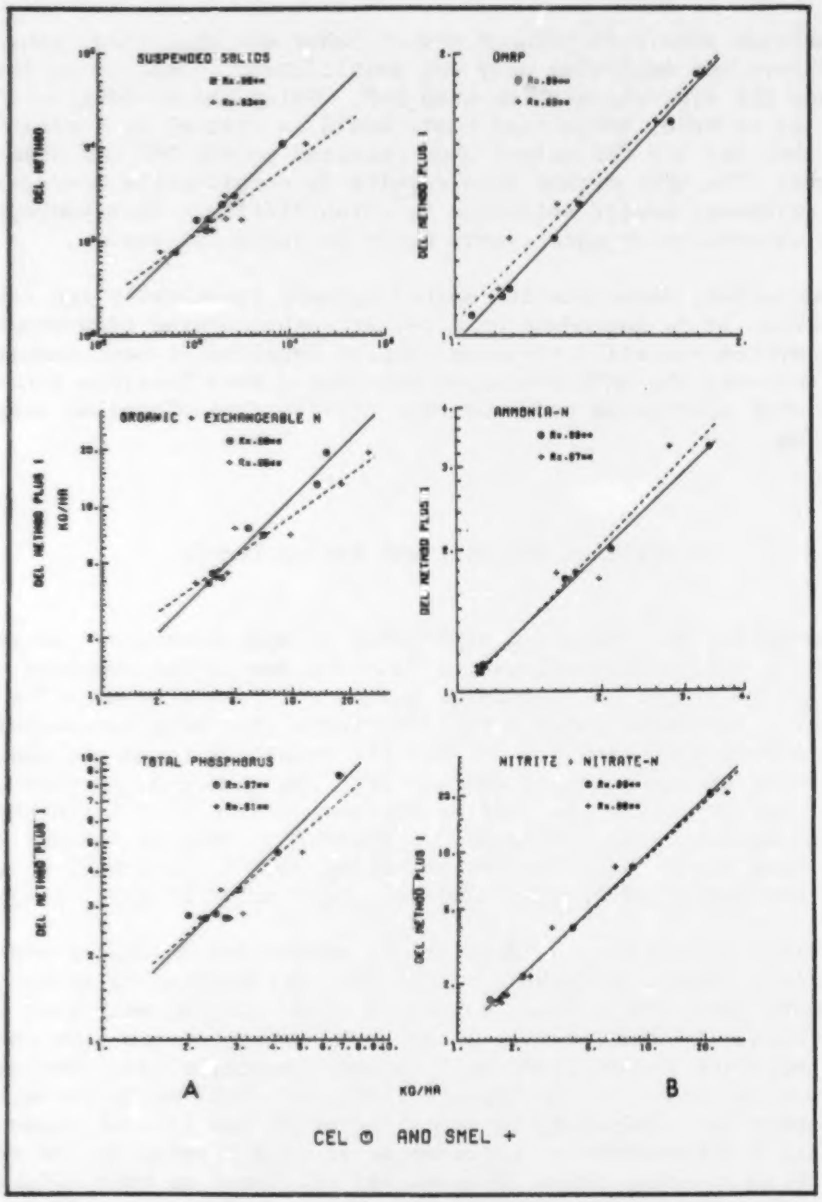


Fig. 10. Comparison of CEL and SMEL event load computations with true values (DEL). Water quality parameters associated with the sediment and those that are dissolved are represented by A and B, respectively. Note each is highly significant at the 99% level (13).

for each event averaged within 5% of the DEL loads for the dissolved parameters and within 20% for the sediment-associated parameters. Results with the CEL method were more consistent than those with the SMEL method for the sediment-associated parameters, although the CEL method generally underestimated suspended solids and associated parameter loads. The SMEL method appeared to overestimate sediment-associated loads during high runoff events.

All methods result in reduced manual labor and analytical costs. The CEL method involves analyzing only one sample/event, compared to three with the SMEL and all discrete samples with DEL. Using the Washington County Project as an example, analytical costs could be reduced by a minimum of 10 and 3 times for the CEL method when compared to the DEL and SMEL methods, respectively. The SMEL method also results in considerable savings of time and money, although sample selection is often difficult when hydrographs are shaped abnormally or when events occur in rapid succession.

In conclusion, while the CEL method appears technically and economically more favorable, it is dependent on a rather sophisticated flow-proportional monitoring system and still requires careful handling of many sample bottles. For these reasons, the SMEL procedure provides a more feasible alternative for established monitoring programs that utilize time-signalled samples or grab sampling.

Monitoring Snowmelt and Spring Runoff

The potential for producing high loads of most parameters during snowmelt and early spring rainfall events is great due to the combined effects of restricted infiltration, saturated soils, and lack of vegetative cover. At station K2, two small early April rainstorms that were successfully monitored in 1978 contributed > 7 times the runoff, 3 times the suspended solids, 4 times the phosphorus, and 10 times the nitrogen, as were contributed by all storms during the rest of the year (Table 7). Researchers studying the agricultural watersheds at White Clay Lake in Shawano County, Wisconsin, have found that, on average, about 70% of the annual water yields and 76% of the annual phosphorus loads occurred prior to May 1 (14).

Many difficulties were experienced in monitoring meltwater and early spring rainfall events in Washington County. The monitoring stations measure runoff rate with a float suspended in a stilling well that fluctuates with changes in water level; water backs up behind the flow control structure, entering the stilling well through lateral pipes. During winter, water allowed to remain in the lateral lines and still wells froze. When the frost depth was extensive, the stilling wells and lateral pipes were insulated and remained blocked while water started flowing in the channels; thus, accurate measurements of early runoff could not be made. Further problems arose when snow and ice blocked the channel when runoff began. Flow became backed up by the snow-filled channels instead of the control structure; therefore, flow measurements were inaccurate.

By the 1979 monitoring season, a procedure had been developed that has effectively handled these problems to date. Preparations in late fall and late winter, before snowmelt, alleviated many of the problems. In November 1978, all lateral lines were capped to prevent water from entering and freezing, and stilling wells were pumped free of water to prevent freezing. Just prior to snowmelt, accumulated snow and ice were removed from the flow control structures and from the channels 5 to 10 m upstream and downstream, allowing the sun to melt the remaining ice and clear a path for runoff. When snowmelt and early spring rains began to cause runoff, the lateral pipes were uncapped and flow measurements made. When temperatures at night fell below freezing, the lateral pipes were again capped and the stilling wells pumped out until melting resumed. This process of capping and uncapping the laterals and periodically pumping out the stilling wells was continued until the spring weather stabilized. While this process is time-consuming, there are few effective alternatives during this important time of year.

CONSERVATION TILLAGE SYSTEMS

Conservation tillage systems have received much attention in recent years. These management techniques for reducing soil loss may also provide farmers with labor and energy savings. Recognizing that whole-watershed studies could not be utilized readily to assess impacts of specific land use practices, technical research focused on plot studies under controlled experimental conditions. Additionally, an ongoing cost-sharing program for conservation tillage in Dane County, Wisconsin, offered a unique opportunity to assess farmers' attitudes toward these systems and to evaluate a program for disseminating new conservation technologies to the farming community.

Infiltrometer Studies

Alternative tillage methods of growing corn were compared in order to evaluate differences between systems in runoff losses of sediment and nutrients and for grain yield (15, 16). The systems studied were conventional tillage (moldboard plowed and disked prior to planting), chisel plow (soil chisel plowed only prior to planting), and no-till (no tillage operations performed prior to planting). The effects of applying manure prior to tillage operations on sediment and nutrient losses were also evaluated.

Materials and Methods

Test plots of 1.3 m^2 were selected randomly on a farm in the Kewaskum South Watershed in Washington County. Four plots--planted to corn--were established for each tillage method for a total of 12 plots. All plots were managed identically except for the different tillage and planting methods. A portion of the corn residue from the previous crop had been removed leaving about 1.7 tonnes/ha (1500 lb/acre) on the surface prior to tillage. Corn variety, fertility, herbicide, insecticide, and planting dates for all plots were identical. Dairy manure was applied at a rate of 45 tonnes/ha (20 tons/acre, wet weight) prior to tillage on two of the four plots for each tillage method. Runoff from the test plots was generated by artificial rainstorms, applied for 1 hr at an average intensity of 14.5 cm/hr (the energy equivalent of about a 50-year, 1-hr storm for the study area) in May, July and September, 1978. Runoff from these storms was measured and samples analyzed to determine nutrient and sediment losses.

Results

Water yield was greatest from the no-till sites as a result of lower infiltration rates. Relatively low runoff volumes occurred at conventionally tilled sites shortly after planting in May. However, volumes increased and approached those of no-till sites in July and September. Runoff volumes from chisel plowed areas were as low or lower than those from conventionally tilled and no-till sites at all sampling times. No consistent effect of manure was observed.

Sediment losses were highly variable among sample plots, particularly in May (Fig. 11). This is most likely the result of local soil variability within the plot areas which would probably be greatest shortly after tillage. High average losses of sediment from conventional and no-till sites with manure in May were, in each case, the result of a single high observation. Elimination of the high value in each case lowered the average to the range of sediment loss observed from the same treatments in July and September. Lower sediment losses were observed from unmanured sites with no-till than from chisel plowed or conventionally tilled sites. Chisel plowed and no-till sites receiving manure had less sediment loss in July and September than equivalent sites without manure. This effect was not observed at conventionally tilled sites.

Phosphorus losses are reported for July and September only, since May results were questionable due to a high concentration of phosphorus in the water used for rainfall simulation. In July and September, municipal well water having a phosphorus concentration of 20 μg/L was used. Because most of the phosphorus was associated with sediment, differences in total P losses were similar to those for sediment losses (Fig. 12). Conventionally tilled sites generally had the highest total P losses due to high sediment losses. Lower total P losses occurred at unmanured no-till sites than at unmanured conventionally tilled or chisel plowed sites. Lowest total P losses occurred at manured no-till and chisel plowed sites.

Higher soluble phosphorus (DMRP) losses occurred at unmanured no-till sites than at unmanured conventionally tilled or chisel plowed sites. Highest losses of DMRP occurred at manured no-till sites (Fig. 13). Losses of DMRP were higher at manured chisel plowed sites than at equivalent unmanured sites. Manure had no consistent effect on conventionally tilled sites.

Although DMRP is considered to be readily available in aquatic systems, less certainty exists regarding the availability of sediment-bound P forms. To better evaluate the impact of runoff on biological productivity in surface waters, an estimate of potentially-available P in runoff suspensions was made, using a recently developed, resin-extractive procedure (17). Results show highest losses from manured no-till sites, due, primarily, to high DMRP losses at these sites (Fig. 14). Lowest losses occurred at manured sites which were chisel plowed because of the lower sediment losses. Losses from manured and unmanured sites which were conventionally tilled were not significantly different from unmanured sites which were chisel plowed or in no-till.

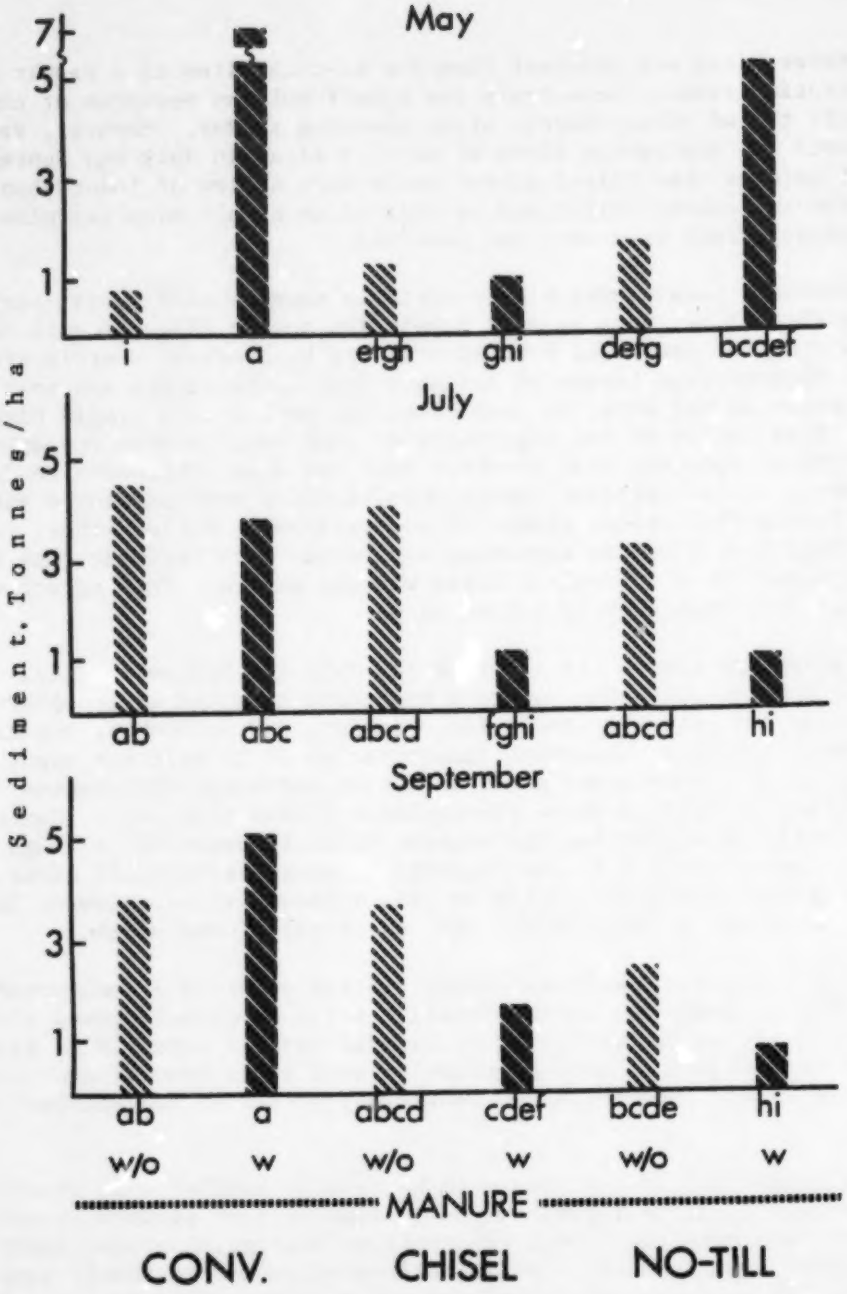


Fig. 11. Mean sediment losses, conservation tillage infiltrometer studies (15). Values with the same letter are not significantly different at the 80% level of probability.

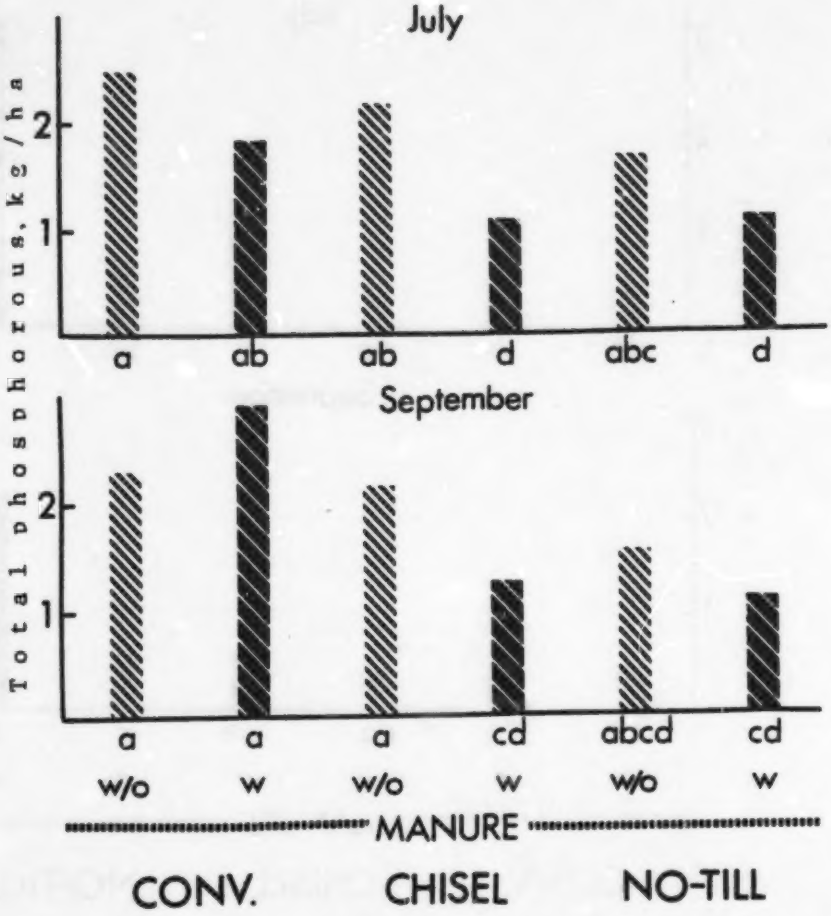


Fig. 12. Mean total phosphorus losses, conservation tillage infiltrometer studies. Values with same letter are not significantly different at the 80% level of probability (15).

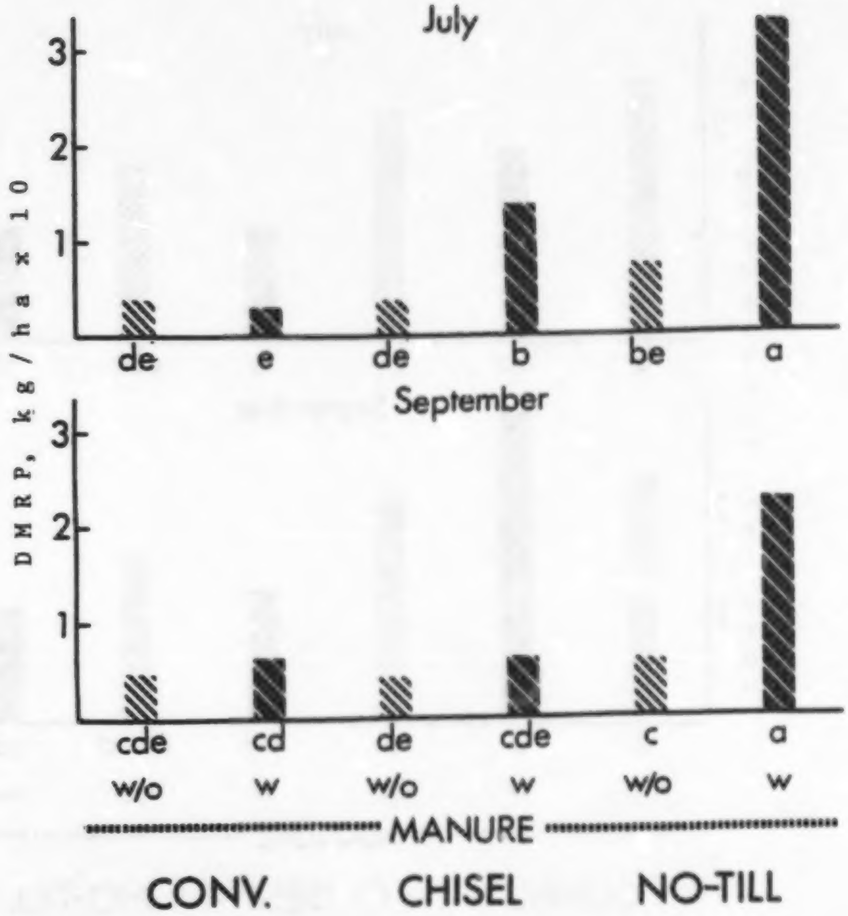


Fig. 13. Mean dissolved molybdate reactive phosphorus (DMRP) losses, conservation tillage infiltrometer studies. Values with same letter are not significantly different at the 80% level of probability (15).

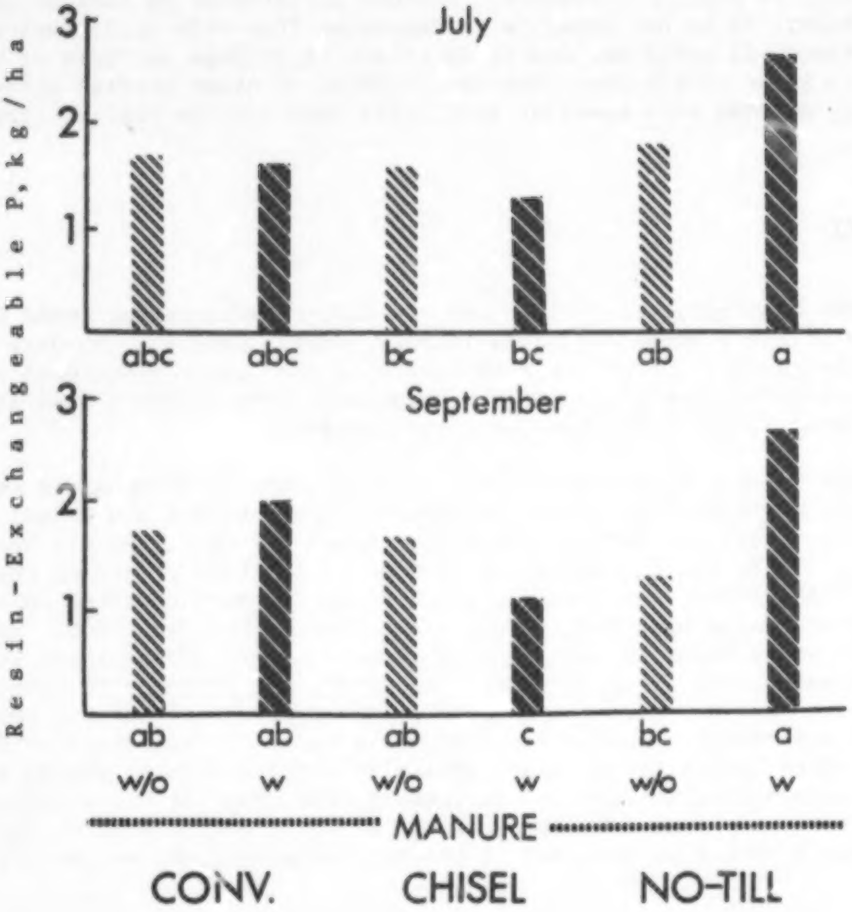


Fig. 14. Mean losses of resin-exchangeable phosphorus, conservation tillage infiltrometer studies. Values with the same letter are not significantly different at the 80% level of probability (15).

Grain yield comparisons

Significantly lower grain yields occurred at no-till sites than at chisel plowed or conventionally tilled sites (Table 12); chisel plowed sites had somewhat lower yields than conventionally tilled sites. No effect of manure was observed. Plant population differences were of similar magnitude to yield differences. Because differences in tillage and population exist, it is not possible to determine from this study whether the differences in yield are due to an effect of tillage on yield or an effect of tillage on population. However, results of other studies using these tillage methods with constant population show similar yield differences.

Summary

The manured no-till sites had the lowest sediment and total phosphorus losses of all systems evaluated in this study. However, the data suggest that the no-till system was less desirable than the conventional or chisel plow systems from a grain yield standpoint. Also, highest available phosphorus losses were from the no-till sites.

The results do not show large or consistent differences in runoff, sediment or phosphorus losses between the conventional and chisel plow methods. There are several possible reasons for this. First, because a portion of the plant residue was removed in the fall preceding the initiation of the study, less residue was left at the surface after chiseling than there would have been if all plant residue had been left. Additional residue would probably have further reduced runoff and sediment losses from the chisel plowed plots. Second, the artificial storms were relatively intense. This may have hidden some of the differences between conventionally tilled and chisel plowed areas that would become increasingly evident at lower storm intensities. Last, unusually intense natural storms occurred prior to sampling in July and September. The crusting and reduction in surface storage caused by these storms may have masked some of the differences that would have been observed if the intense storms had not occurred.

Case Study of Farmers' Attitudes and Experiences with Conservation Tillage

During 1976 and 1977, The Dane County Soil and Water Conservation District, with the assistance of SCS and Dane County Extension, offered to cost-share conservation tillage and no-till practices as a direct incentive to encourage use of conservation tillage. In order to assess farmers' experiences with and attitudes toward conservation tillage systems, a survey was conducted during the summer of 1978 (18).

Fifty farmers who had participated in the cost-share program during 1976 and/or 1977 were interviewed at their farms. Questions in the survey dealt with the types of tillage systems used and the operations and chemical

Table 12. Grain yields and plant populations for three tillage systems, with (A) and without (B) manure (15)

Plant yield and population*	Tillage Systems					
	Conventional		Chisel plow		No-till	
	A	B	A	B	A	B
Yield, bushels/acre	145ab**	149a	138b	137b	115c	118c
Plant population, plants/acre	20,300ab	20,600a	18,900bc	19,200bc	15,900d	16,600d

*Bushel/acre = 62.76 kg/ha; and plants/acre x 2.47 = plants/ha

**Values followed by the same letter are not significantly different at the 95% level of probability.

applications involved in using each system; degree of satisfaction with conservation tillage in terms of economics, yields, and soil and water conservation also were evaluated.

In addition, comparative short-run budgets were developed for corn grown under conventional, chisel plow and no-till systems (Table 13). Calculations were made on a per-acre basis so that cost estimates for most farms could be derived from the budgets. The chisel plow system with a disking operation gave a net monetary return 3% greater than conventional tillage. By eliminating the disking operation, the monetary advantage of chisel plowing increased to 6.3%. Reductions in tillage operational costs more than offset the increased herbicide expenses associated with minimum tillage. The no-till system had a 15% lower net return than conventional tillage, although total costs for no-till were the lowest of the systems analyzed. The lower net return was due to an assumed 10% reduction in crop yield with no-till, a reduction based upon experimental data and opinions of farmers. A greater risk of yield reduction is involved with no-till due to a reliance on chemical pesticides and favorable environmental conditions.

Results from the survey suggest that farmers are generally pleased with--or at least intrigued by--conservation tillage. On the other hand, farmers showed less satisfaction with no-till (Fig. 15). Most farmers did not experience significant reductions in yields from conservation tillage as compared to conventional tillage (Fig. 16). In fact, 18% of those surveyed reported higher yields with conservation tillage. Of the farmers interviewed, 40% experienced a significant yield reduction with no-till. However, a large number of interviewees had tried no-till only during 1976 when Wisconsin experienced severe drought conditions which had an especially adverse impact on no-till corn planted in stands of hay, because the chemicals used to kill the hay often were not very effective. This may account for the poor yields.

Farmers' reasons for initially trying conservation tillage were primarily to save soil, time and money (Fig. 17). Most farmers believed that conservation tillage saved time and soil; 40% felt there was no financial saving over conventional systems. It should be noted that an average reduction of only one tillage operation compared to conventional tillage was achieved with the conservation tillage methods employed by the interviewees. Further reduction is possible and would result in greater time, money and soil savings.

The major problems reported by farmers using minimum tillage were weeds and insects (Fig. 18). With no-till, additional problems involving planting and germination were reported. Weed and insect problems may reflect improper chemical application or poor effectiveness of the chemicals themselves. More education for farmers with reference to application, timing, and mode of operation of herbicides and pesticides could reduce these problems.

Responses to questions concerning the flow of information about conservation tillage are depicted in Figure 19. Conversations with neighbors, articles in newspapers, magazines and pamphlets, and the extension efforts of government agencies provided most farmers with their initial information concerning conservation tillage.

Table 13. Corn budgets under three alternative cultivation systems

	Conventional			Chisel Plow			No-Till		
	Quantity	Unit price	Per acre	Quantity	Unit price	Per acre	Quantity	Unit price	Per acre
					RECEIPTS				
Yield/acre***	100 bushel***			100 bushel			90 bushel		
Price/acre		$2.40			$2.40			$2.40	
Gross returns/acre			$240.00			$240.00			$216.00
					COSTS				
Fertiliser:									
nitrogen	100 lb***	$0.25	$ 25.00	100 lb	$0.25	$ 25.00	100 lb	$0.25	$ 25.00
phosphorus	45 lb	0.21	9.45	45 lb	0.21	9.45	45 lb	0.21	9.45
potassium	45 lb	0.08	3.60	45 lb	0.08	3.60	45 lb	0.08	3.60
corrective		4.50	4.50		4.50	4.50		4.50	4.50
TOTAL fertiliser costs			$ 42.55			$ 42.55			$ 42.55
Insecticide	8 lb	$0.86	$ 6.88	8 lb	$0.86	$ 6.88	8 lb	$0.86	$ 6.88
Herbicide:									
Atrazine	2 lb	$2.44	$ 4.88	2 lb	$4.88	$ 4.88	2 lb	$2.44	$ 4.88
Lasso	2 qt***	4.00	8.00	2.5 qt	4.00	10.00	2.5 qt	4.00	10.00
TOTAL herbicide costs			$ 12.88			$ 14.88			$ 14.88
Seed	23,000 kernels	$35.00/80,000	$ 10.06	25,300 kernels	$35.00/80,000	$ 11.07	25,300 kernels	$35.00/80,000	$ 11.07
Labor:*									
machinery operation	3.6 hr/acre			2.7 hr/acre			1.7 hr/acre		
other	1.8 hr/acre			1.4 hr/acre			0.9 hr/acre		
Machinery:**									
tractor			$ 1.12			$ 1.49			$ 1.12
plow			5.60		chisel plow	2.91		no-till planter	1.44
fertiliser spreading (custom)			3.24			3.24			3.24
disk			6.51			3.26			—
stalk chopper			3.67			3.67			3.67
planter			3.61			3.61			—
combine			36.05			36.05			36.05
cultivator			1.33			1.33			—
sprayer			4.46			4.46			4.46
dryer			15.00			15.00			15.00
TOTAL machinery costs			$ 80.59			$ 75.02			$ 64.98
TOTAL COSTS			$152.96			$150.40			$140.36
					NET RETURNS				
			$ 87.04			$ 89.60			$ 75.64

* Time committed to labor is given without costs due to wide variations in individual farmers' assessment of labor value.
** Includes capital and operational costs.
*** Bushel = 56 lb = 25.4 kg (1 kg = 2.205 lb); 1 qt = 0.95 L; 1 ha = 2.47 acre.

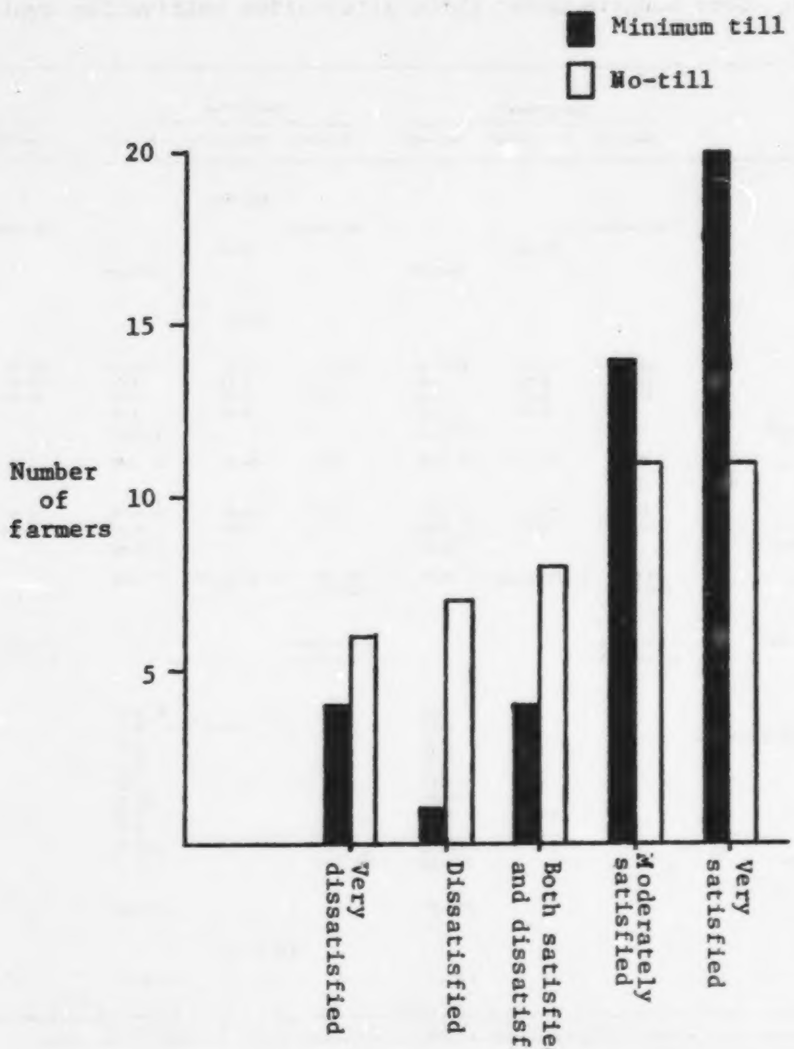


Fig. 15. Degree of satisfaction with conservation tillage (18).

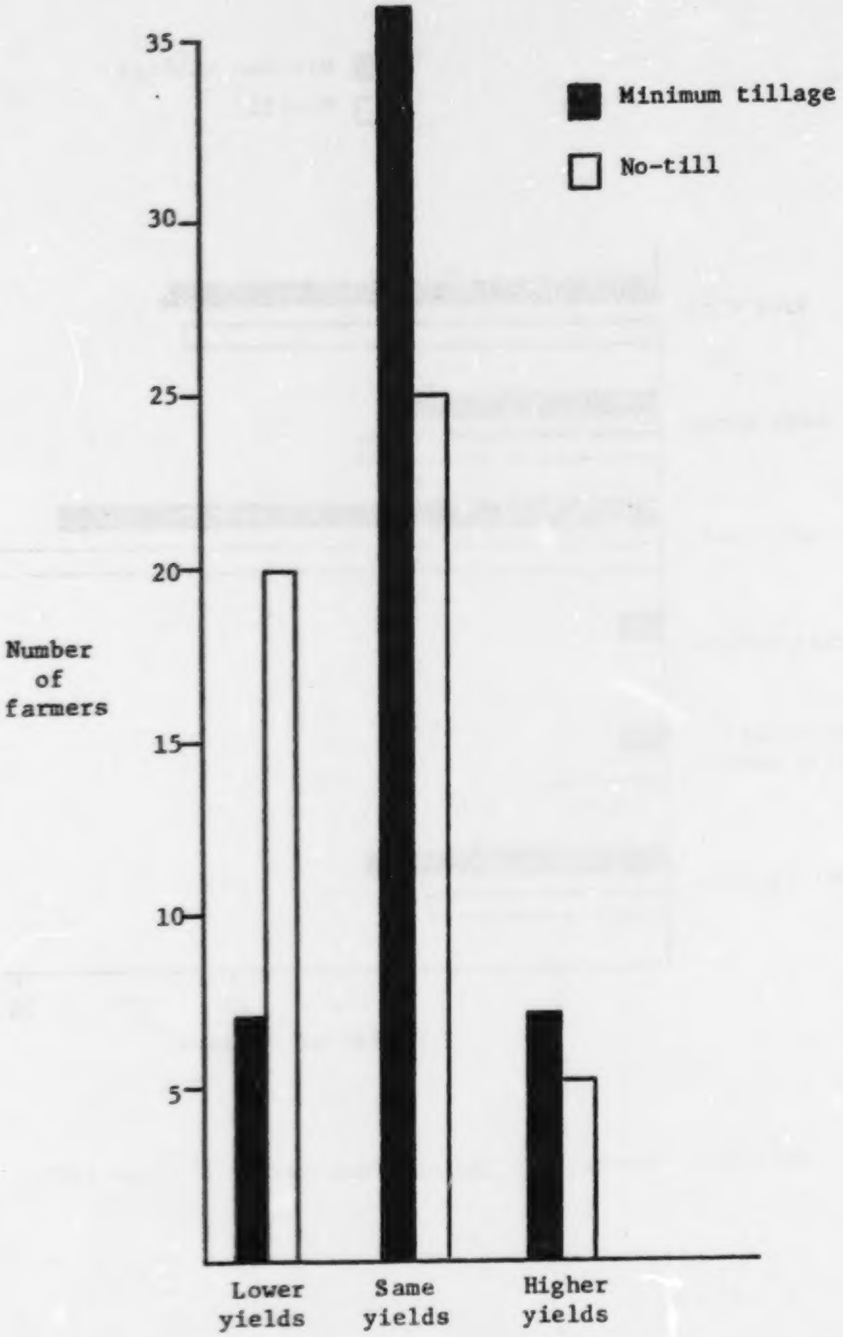


Figure 16. Corn yields with conservation tillage as compared to conventional tillage (18).

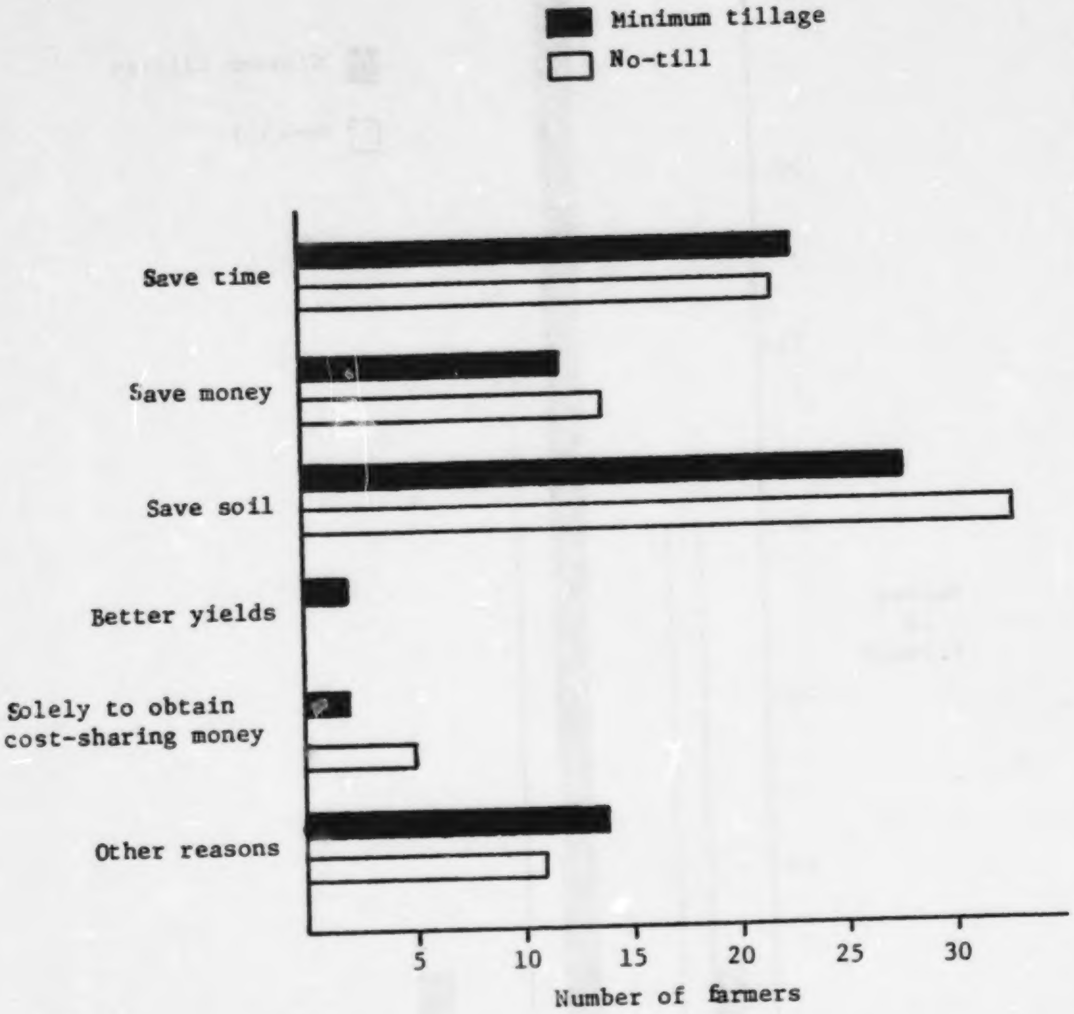


Fig. 17. Reasons for trying conservation tillage (18).

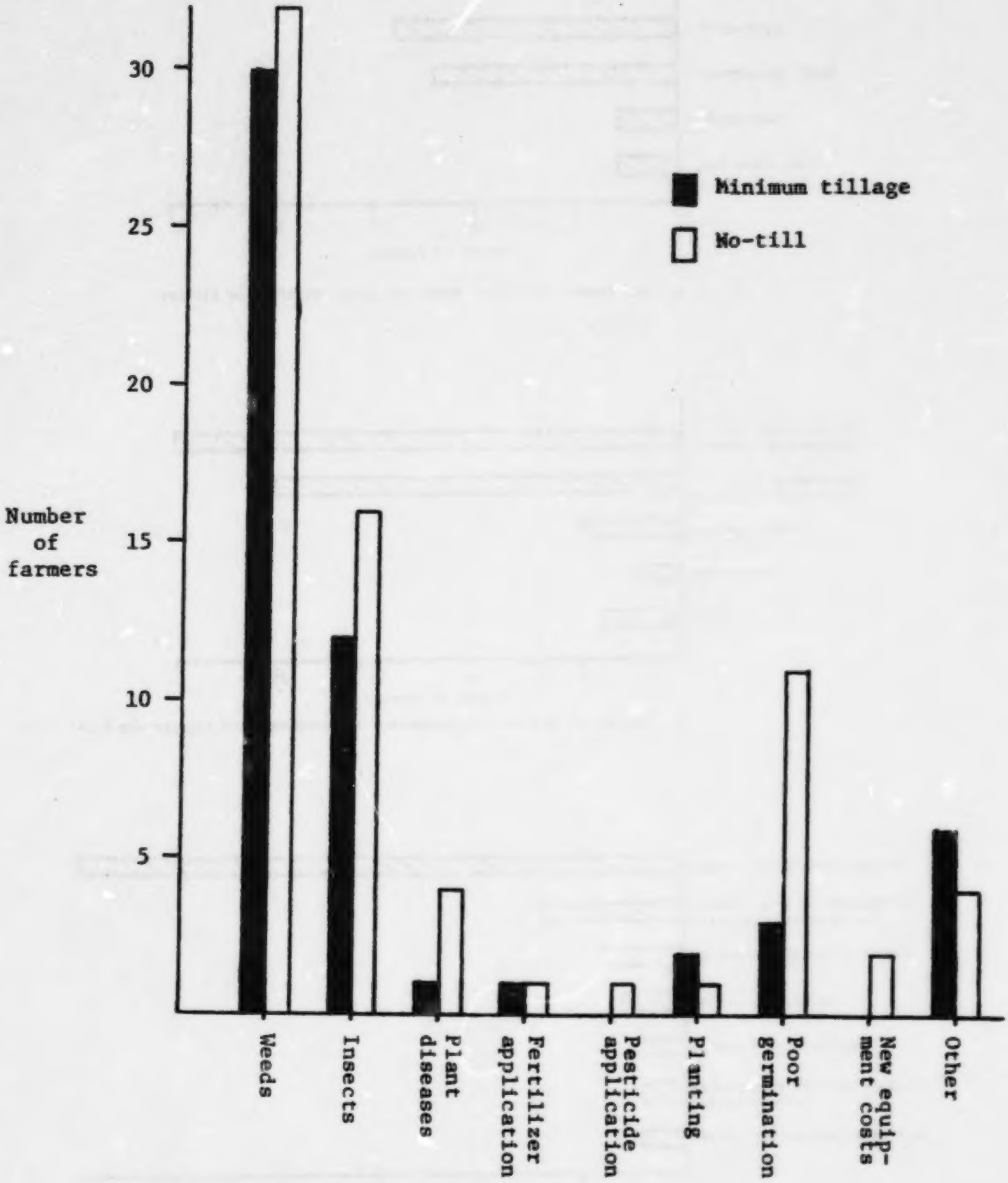
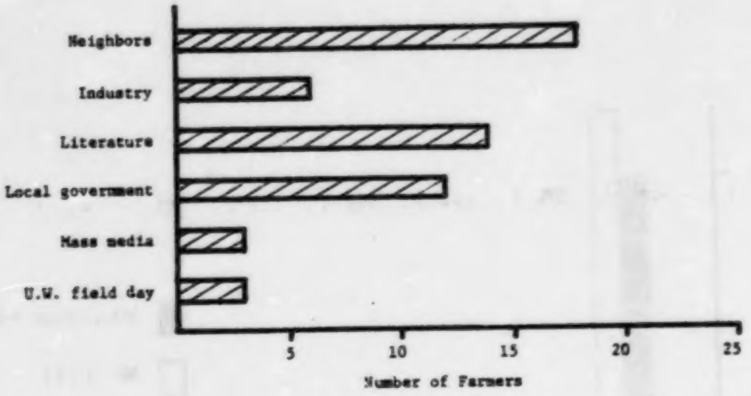
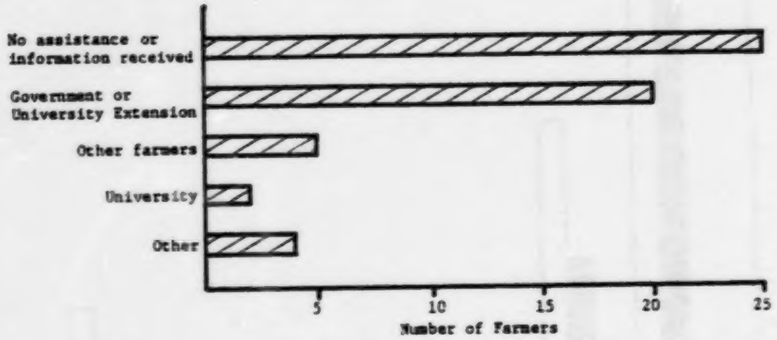


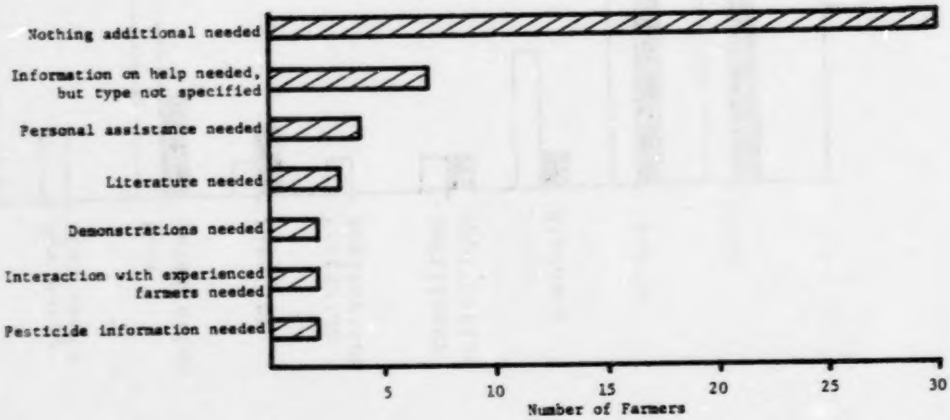
Fig. 18. Problems encountered by farmers using conservation tillage (18).



A. How farmers initially found out about conservation tillage



B. Sources of information/assistance when conservation tillage was first tried



C. Additional information needed about conservation tillage

Fig. 19. Flow of information concerning conservation tillage to farmers (18).

When actually using conservation tillage for the first time, 50% of the farmers stated that they received no additional information or assistance; those who did receive assistance stated that most help came from local agencies, with neighbors playing a less significant role.

When asked what type of additional assistance and/or information they would have desired when adopting conservation tillage initially, most farmers said they needed nothing additional. Those respondents that did express a desire for more help were often non-specific about the type of help. However, based on the farmers' primary sources of information available to farmers, assistance would probably reach farmers most effectively through local government agencies and farmer-oriented publications.

In summary, farmers appear to find some conservation methods appealing enough to adopt them gradually whether or not direct monetary incentives are available. Research findings and management recommendations provided through local government agencies and farm oriented literature could help to encourage adoption and effective application of these systems. Farmers do not, however, change their habits quickly nor without evidence that the change will be beneficial. In this respect, it is not likely or even preferable that farmers rapidly and totally adopt conservation tillage systems; putting too much pressure on farmers to adopt them may have a detrimental effect.

EROSION CONTROL AT RESIDENTIAL CONSTRUCTION SITES

The Problem

Residential construction activities can have a significant impact on water quality (19). The potential for problems to develop depends to a large extent on the physical characteristics of the site. For example, floodplains, steep slopes and areas with high water tables present special problems. During plat development topsoil and vegetation are often removed completely and topsoil is stockpiled while streets and utilities are laid out. A site may remain in this erosion-prone state for several years before construction is completed, especially if housing market conditions are unfavorable. Severe impacts--particularly when several units are built at once--have been documented in Germantown.

The most significant water quality problems associated with home construction activities arise from:

1. Exposed and unprotected soil throughout subdivision development which is highly vulnerable to erosive forces.
2. Excavated soil placed in large mounds near or in the streets, directly connecting sediment sources to storm sewers.
3. Unlimited access to lots by vehicles and heavy equipment, causing gully formation and tracking of soil into streets.
4. Rooftop drainage and water pumped from flooded basement foundations (dewatering) falling onto exposed areas, thereby increasing erosion and transport of sediment to storm sewers.

Project Efforts

Past research and most subdivision ordinances (including those being adopted in Washington County as a result of this project) generally have addressed sedimentation problems solely during the initial site development phase. The actual home construction process has been largely ignored, both from a technical and institutional standpoint. During the course of the project, the magnitude of the erosion problem during home construction became evident. Onsite control measures and practices that could be implemented without imposing significant financial burdens were identified. During the summer of 1978, an attempt was made to convince individual builders to adopt some of these practices in Germantown's Old Farm Annex, adjacent to the G3 monitoring site. Unfortunately, these efforts were not received favorably and few have responded to the suggestions presented. The Village of Germantown, however, is currently working on methods of incorporating erosion control provisions into their Building Permit requirements.

Control Techniques

Many of the control techniques identified do not involve additional cost. Often minor adjustments in construction methods and careful timing and execution of land-disturbing activities are all that is needed. Since most construction activities occur during work performed by subcontractors who are onsite for a very short time, cooperation and communication between builders and subcontractors are essential if mitigating measures are to be effective.

Practices which may help to reduce soil loss during construction include:

1. Scheduling construction activities to minimize land disturbance during peak runoff periods.
2. Depositing excavated soil from basements away from the street curb--in the backyard or sideyard area--which will increase the distance eroded soil must travel to reach the storm sewer system.
3. Using one route (preferably the future driveway) to approach the house with trucks and heavy equipment.
4. Backfilling basement walls as soon as possible and rough grading the lot thereby eliminating large erodable soil mounds and preparing the lot for temporary cover.
5. Installing a trench or berm if the lot has a soil bank higher than the curb and moving the bank several feet behind the curb.
6. Removing excess soil from the sites as soon as possible after backfilling to eliminate any sediment loss from surplus fill.

Additional practices for reducing erosion, often requiring greater financial expenditures, include:

1. Covering a minimum area of 20 to 30 feet (6.5 to 9 m) behind the curb--if it is not feasible to stabilize the entire lot--with a protective material such as filter fabric, mulch or netting. This covering can be installed before backfilling, provided the excavated soil is placed in the backyard area and the lot has been rough graded. Utility lines can be installed by removing the protective cover and replacing the cover after backfilling.

2. Applying gravel to the driveway area and restricting truck traffic to this one route. Driveway paving can be installed directly over the gravel.

3. Installing roof downspout extenders that aid in dispersing rainwater or diverting it to protected areas.

4. Covering sides and backyards with mulch, netting or other soil stabilizers after the foundation is backfilled to reduce erosion from these areas.

5. Stabilizing backfilled lots by seeding and mulching or sodding as soon as practical, to minimize erosion as well as to make the area more pleasant visually.

Several issues became apparent during this study. Firstly, a need exists for information directed to developers, builders, and subcontractors describing how their working practices can cause serious soil loss and water quality degradation. Secondly, practical and economical methods minimizing sediment loss must be further tested and publicized. Finally, stronger incentives must be developed to insure that builders and subcontractors minimize the effects of their actions on sediment loss.

MODELS AND PREDICTIVE TOOLS

In the initial phase of the project it was realized that many of the technical questions being asked by those formulating sediment control programs could not be answered solely by the monitoring data. Models were examined as a means of organizing available data; of projecting implications of alternative sediment control strategies; and of helping to determine which factors have the greatest impact on sediment and other water pollutant yields. While all models must be applied cautiously and only within the limitations under which they were developed, they provide an important and often the sole means of evaluating the effects of many key policy decisions.

Skopp and Daniel (20) made a systematic review of the variety of approaches to modeling presently available, within the context of water quality management. Each group of models was evaluated on the basis of five criteria, namely, accuracy; simplicity; adaptability; flexibility; and viability. While some fairly sophisticated, deterministic and stochastic models are available, they do not appear to provide much better predictions than statistical models that are less expensive and easier to use for management purposes. In general, the modeler should choose the simplest alternative that still meets the modeling objectives.

Miller et al. (21) developed a series of computer programs to predict gross annual soil loss on a watershed basis by application of the Universal Soil Loss Equation (USLE). The programs provide an easy to use, flexible and standardized means of organizing base data and applying the USLE to small or large land areas. They can be used to predict the effects of changing land use patterns and conservation practices on soil losses, e.g., these models were used to estimate cropland soil loss in Washington County and other southeastern Wisconsin counties, based on a 2% land use and management inventory (22). This evaluation was used to estimate the effect of the ordinance proposed by the Washington County Project institutional group on soil loss on a county-wide basis (23).

Berkowitz (24) has adapted a watershed model, initially developed under the direction of Novotny (25), to predict runoff and sediment yields from agricultural watersheds. This model was linked with a farm management model in order to evaluate on-the-farm impacts of regulations establishing soil loss constraints, as well as the expected changes in watershed sediment yields (26). This analysis was applied in one of the monitored watersheds in Kewaskum, where dairy farming is the dominant land use. The superiority of a conservation tillage system from economic and sediment loading perspectives was demonstrated. Sediment yield predictions were most sensitive to values used for soil permeability and surface depression storage; therefore, to improve evaluations of the effectiveness of management practices, additional information is needed on how these two factors vary under different management conditions.

Phosphorus, which is often transported to waterways attached to sediment particles, is a major nonpoint source pollutant in its own right. While phosphorus yield from a watershed is relatively easy to measure, it is much more difficult to determine how much P is contributed by each upslope source. Attention was focused on three sources of phosphorus contamination, namely, cropped fields, barnyard manure, and manure spread on fields. Additional loads of phosphorus from pasturelands, septic tanks and urban areas have not been considered in detail.

Miller (27) developed a model for predicting P loads from agricultural lands; different forms of phosphorus are described. Soluble P loads were predicted with an empirical equation developed by regression analysis of data obtained from nutrient loading studies conducted in the Midwest. Significant factors affecting predicted dissolved phosphorus loads include average annual precipitation, area, slope, soil type, land use, conservation practices, and residue management. The model derived is shown in Table 14. All parameters were significant at least at the 90% confidence level, and the regression equation as a whole explained more than 50% of the variation in loading. The sediment-associated phosphorus loads were estimated as a function of USLE-predicted soil loss, the phosphorus content of soil, an enrichment ratio (which accounts for the tendency of eroded sediment particles to be smaller and have a high phosphorus content than the parent soil), and a sediment delivery ratio. By combining these two techniques, predictions of total phosphorus loads from agricultural watersheds were obtained. Land use exerted the greatest influence on the magnitude of predicted loading rates. While hay lands contributed relatively small sediment-bound phosphorus loads, they were the largest contributors of soluble phosphorus. This model is capable of evaluating the impact of changing land use and erosion control practices on phosphorus loading rates. Predicted loads, however, are long-term average estimates and do not account for the effects of extreme variations in the magnitude and timing of annual weather phenomena.

Moore et al. (28) refined a method for predicting total phosphorus loadings from livestock wastes in barnyards and on manure-spread fields. This method was applied to determine contributions of phosphorus from livestock to the lakes from the Wisconsin portion of the Great Lakes Basin. Factors considered in predictions include variations in manure phosphorus content among animal types, regional topography, animal density, location of barnyards with respect to channels, and manure handling techniques. Predicted annual phosphorus loads for the study area as a whole ranged from 110 to 350 g/animal unit/yr (1 animal unit represents 1,000 lbs of live weight animal equivalent). Winter-spread manure was predicted to account for about 35% of the annual phosphorus load from manure sources, while barnyard concentrations of dairy cattle, beef cattle and hogs contribute roughly 47, 17, and 1%, respectively.

The total phosphorus loads from the Kewaskum watersheds as predicted by the cropland and livestock models were compared with the monitoring data for 1977 and 1978 (Table 15). It should be noted that these models incorporate many assumptions which cannot be satisfactorily verified. They are generally capable of yielding only long-term predictions and do not characterize many sources of variability. The predictions shown in Table

Table 14. Soluble reactive phosphorus loading (SRPL) model[*]

$SRPL = Const + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7$[**]

SRPL = Soluble reactive phosphorus loading (kg/ha/yr)

Const = 0.2164

$B_1 = -0.0025$ X_1 = average annual precipitation (cm)

$B_2 = -0.0015$ X_2 = area (ha)

$B_3 = 0.0093$ X_3 = slope (%)

$B_4 = -0.1616$ X_4 = 1 if clay loam soil, else 0

$B_5 = 0.1518$ X_5 = 1 if corn,

$= 0.0932$ = 1 if oats,

$= 0.2675$ = 1 if hay,

$= 0.1837$ = 1 if pasture, else 0

$B_6 = -0.1700$ X_6 = 1 if up and down plowing, else 0

$B_7 = -0.0949$ X_7 = 1 if residue left or incorporated, else 0

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[*] Model derived by Miller (27) from analysis of midwestern watersheds <100 ha.

[**] $R^2 = 0.57$
Standard error of estimate = 0.06
All parameters significant above the 90% level.

Table 15. Predicted total phosphorus loads from the Kewaskum Watersheds

Site	Year	Livestock contribution*	Cropland contribution**	Total predicted load (livestock plus cropland)	Monitoring data***
		kg/ha+			
K1	1977	0.34	0.41	0.75	0.41
	1978				0.13
K2	1978	0.65	0.36	1.01	0.35
K3	1977	12.73	1.10	13.83	19.65
	1978				1.02

*Based on Moore's model (28). Major assumptions are:

a. Only barnyards and manure spread within 100 ft (30 m) of a defined channel or ditch contribute phosphorus to surface runoff.

b. 5% of the phosphorus excreted will enter surface runoff from barnyards on an annual basis.

c. 10% of the phosphorus in manure spread on frozen ground is carried away in runoff.

d. Within the 100 ft (30 m) critical distance, the phosphorus in surface runoff is linearly attenuated, e.g., 0% removal right next to the channel, 50% removal at 50 ft (15 m), 100% removal at 100 ft (30 m) and beyond.

e. All "delivered" phosphorus, as derived above, is presumed to flow from the watershed (i.e., in-channel delivery ratio is presumed to be 1).

**Based on Miller's model (27).

***Monitoring results generally do not include any snowmelt or early spring rainfall events.

+In all cases, total watershed area was used to compute loadings.

15 were based on the crop and barnyard management conditions of 1977 and do not account for management changes in 1978.

Keeping these limitations in mind, the correspondence between monitored and predicted data appears reasonable. Looking at data from sites K1 and K6, predicted total phosphorus loads are 2 to 6 times higher than the measured loads. The predictions are probably too high because neither model accounts for P attenuation during instream transport. However, it also is likely that the monitored data are artificially low as they generally do not include early spring runoff phosphorus contributions which could have been substantial.

For K4, predicted loadings are slightly lower than monitored loadings in 1977, and 14 times higher in 1978. It is reasonable that the unusual climatic event which resulted in extremely high phosphorus losses from this watershed in 1977 would not be reflected in the long-term average model predictions. In 1978, the difference between monitored and predicted phosphorus loadings can be explained partly by the factors mentioned above, and partly by the fact that barnyard runoff controls were installed and effective by 1978. When the phosphorus contribution from the K4 barnyard (11 kg/ha) is subtracted from the predictions, predicted losses are only three times the measured losses in 1978.

Comparision of the predicted values of cropland versus livestock phosphorus sources indicates that in the absence of control measures, livestock contribute 45% and 65% of the total phosphorus load at K1 and K6, respectively, and 92% of the load at K4. Barnyards were estimated to contribute about 88% and manure spread on fields 12% of the annual phosphorus load generated by livestock in Kewaskum.

FUTURE RESEARCH NEEDS

From the research efforts of the Washington County Project, insight has been provided into some of the complex relationships between land management, erosion and water quality; however, many questions remain unanswered. Several areas needing additional study have been identified as follows:

1. The effectiveness of agricultural and housing construction management practices in improving water quality should be further documented. More data need to be collected especially during the late winter-early spring period. To determine which practices are preferable, their influence on such basic hydrologic features as depression storage and infiltration should be better quantified.

2. The processes controlling the sediment delivery ratio (SDR) in a watershed and the impact of alternative management practices on the SDR should be investigated.

3. Methods used for nonpoint source pollution monitoring should continue to be evaluated and improved.

4. Predictive models that relate agricultural land management and urbanization practices to the generation and transportation of pollutants to waterways should be further developed and tested.

5. The attitudes of landowners towards alternative methods of controlling sediment and other nonpoint source pollutants should be examined further.

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PART III

EDUCATION AND INFORMATION PROGRAM
FINAL REPORT

by

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INTRODUCTION

The education and information aspect of the Washington County Project was unique among P.L. 92-500 public participation efforts in that it focused primarily on problems relating to urban and rural sediment pollution. Thus, although the structure of the education and information program was similar to those developed in conjunction with Section 208 planning in Wisconsin, the scope of the project effort was limited to selected non-point sources of pollution.

Early in the course of the project, a staff for the education and information effort was assembled. A director was identified and a print media specialist and a photographer were hired on a part-time basis to provide support. A local coordinator was also hired in Washington County to work with the county resource agent to carry out public participation activities at the local level. Specialists from the University of Wisconsin-Madison, the Wisconsin Department of Natural Resources, the University of Wisconsin-Extension, and the Wisconsin Board of Soil and Water Conservation Districts were identified to provide support for the local activities, but the major responsibility for carrying out those activities was placed on the local project representatives.

During the course of the project, staff--primarily graduate students--were added to meet specialized education and information needs, e.g., with the school program (discussed later). Direction for the education and information group was determined by a committee composed of the project staff and specialists from University Extension, the State Board of Soil and Water Conservation Districts, and the Southeast Wisconsin Regional Planning Commission.

Project advisors, including representatives of the Village of Germantown, the Washington County Board, the Town of Kewaskum, and the State Board of Soil and Water Conservation Districts, were identified. Among their tasks was the review and approval of the activities, strategies, and materials of the education and information program.

The goal of the education and information phase of the Washington County Project was to have a diverse group of target audiences made aware of the magnitude of and alternative solutions to the sediment problem in rural and urbanizing areas. The objectives may be divided into two categories, informational and interactional program development. Informational activities are defined as one-way information flows either from the project to the identified audiences or vice versa, whereas interactional activities are two-way information flows as dialogue or interaction between the identified audiences and the project.

Information program objectives were:

1. To increase awareness of the sediment problem.
2. To increase understanding of the solutions available.
3. To provide educational materials.
4. To make the public aware of the goals and objectives of the Washington County Project.

Interactional program objectives were:

1. To provide forums for public participation in all aspects of the project.
2. To provide opportunities for various segments of the public to observe the results of the project.

The first step in the process of information and involvement was the identification of potential audiences. These were defined as:

1. The general public.
2. Interested and affected publics including:
    a. Economic interests such as farmers, contractors, subdividers, etc.
    b. Environmental interests like lake property owners, Audubon Society, etc.
    c. Civic groups such as Lions, Kiwanis, Rotary Clubs, etc.
3. Decision-makers:
    a. Washington County Soil and Water Conservation District.
    b. Other county officials (elected and appointed).
    c. Town officials (elected and appointed).
    d. Municipal officials (elected and appointed).
4. Regional audiences:
    a. Southeastern Wisconsin Regional Planning Commission.
5. State audiences:
    a. State Board of Soil and Water Conservation Districts.
    b. Wisconsin Association of Conservation Districts.
    c. Wisconsin Department of Natural Resources.
6. National and international audiences:
    a. International Joint Commission.
    b. U.S. Environmental Protection Agency.

INFORMATIONAL ACTIVITIES

Informational strategies were designed to meet the needs of the identified publics. Brochures describing the Washington County Project and nonpoint source pollution problems were prepared for general use. These were distributed in Washington County through the county resource agent and the county Soil and Water Conservation District. A major publication on all aspects of the nonpoint source problem was also developed by project staff. A display featuring these brochures was developed for the Washington County and Wisconsin State Fairs as well as the Wisconsin Association of County Boards and Wisconsin Association of Conservation Districts annual meetings.

Other informational materials for general use and for specific publics included a slide tape set of 57 slides describing nonpoint source pollution and the efforts of the Washington County Project in dealing with this problem. The program, "Clean Clear Water," was shown to numerous groups in Washington County and used in classrooms and at meetings across the state. A twenty-one minute color film, "Runoff: Land Use and Water Quality," was also produced by the project and is receiving nationwide attention.

Press releases generated by project staff were received favorably by area newspapers. A series of background articles on the project was carried in full by local weekly newspapers. In-depth interviews with participants in the project in the Germantown and Kewaskum areas were featured. Specialized articles designed for use in agricultural publications were also developed. Feature stories on project activities and accomplishments were distributed statewide through county extension resource agents. A press tour for local and regional media representatives was organized in conjunction with the International Joint Commission project on the Menomonee River. Monitoring strategies as well as legal, institutional, and economic complexities of nonpoint source pollution control were discussed in detail in an attempt to provide essential background information for the working press. Eighteen radio programs--nearly 4 hr of radio time--and four television programs were devoted to project activities.

Professional papers were developed for identified expert audiences. Many were submitted to technical journals for publication. References to these papers may be found in other sections of this report. Additionally, papers were presented by project staff at a number of important conferences, including the 10th Annual Cornell University Conference, the Second and Third Annual Conferences of the Wisconsin Chapter of the American Water Resources Association, the Second International Conference on Transfer of Water Resources Information, three U.S. EPA sponsored workshops on nonpoint source pollution, and numerous conferences on environmental education.

INTERACTIONAL ACTIVITIES

Interactional strategies also were developed for the identified audiences. The extension resource agent from Washington County contacted many local community groups like the Lions, Kiwanis, Rotary, League of Women Voters, etc. throughout the county. Over the course of the project more than 80 presentations on sediment, nonpoint source pollution and the like were made to these groups to a total audience in excess of 4000 people. This community involvement mechanism was augmented by presentations to the local decision-makers by project staff and the resource agent. A community meeting was held in cooperation with the Southeastern Wisconsin Regional Planning Commission water quality planning program in order to examine water quality problems and potential solutions and determine public perceptions and expectations on these matters. This meeting was attended by a broad segment of the local population. Over 600 people visited project monitoring stations as part [illegible] 19 organized tours.

The project in cooperation with the Washington County Land Use and Parks Department and the County Extension Office developed a program in which local farmers designated areas to be zoned exclusively for agriculture. Over 400 people in 9 towns in the county participated in this program. Following the meeting, 3 regional meetings were held with the same group of people to determine conservation concerns and to establish priorities among the county's water resources.

These series of meetings which were held in the latter stages of the project were excellent public participation efforts. Citizens identified urban sprawl in rural areas, high taxes on farmland, and loss of farmland to development as their key concerns. Rural residents expressed concern that the urban governments were making insufficient effort to control nonpoint source pollution. Participants felt that progress in nonpoint control was being made in rural areas and that city residents were receiving the most benefits. Overcrowding and overuse of the somewhat limited water resources of the county also was a concern. These feelings, conveyed to decision-makers, should form the backdrop for locally initiated land use and water quality decisions.

Four regional workshops were held in the fall of 1977 for Soil and Water Conservation District Supervisors and federal, state and local agency personnel with an interest in nonpoint problems. These workshops included presentations and discussions on technical, legal and institutional problems and priorities. They were held in Greeen Bay, Mount Horeb, Eau Claire and Waukesha. These workshops attracted over 400 people who were involved in water quality improvement programs as technicians or decision-makers. Information on the Washington County Project was disseminated to other counties during the session.

Additional information and educational needs were identified and met during the course of the planned activities. One of these was to provide information for teachers and schools on nonpoint source pollution and proposed remedial actions and agencies.

Early in the course of the project, the education and information staff began working with county schools to inform teachers about local soil and water problems. Presentations were made during teacher inservice days. This brief exposure increased teacher awareness of local issues but did not give teachers an adequate background to prepare curricula materials for their students. A one credit seminar "Understanding Nonpoint Pollution" was held during the spring semester of 1977. Participants were introduced to physical, biological and institutional aspects of soil and water problems. Part of each session was devoted to a review of available curricula materials. The seminar was attended by teachers of various disciplines and grade levels as well as citizens and agency employees.

Development of curricula related specifically to the soil and water resources of the Kettle Moraine geography and its eventual adoption by public and private schools in Washington County required a still more intensive program. Project staff worked closely with school administrators and teachers to write a proposal which was submitted to the Wisconsin Department of Public Instruction in January of 1977. The project was funded for Fiscal Year '77 from the Federal Elementary and Secondary Education Act of 1965, Title IV-C. This funding, along with extensive support from the Washington County Project, sustained the following curriculum development project.

The project goal during the initial year was to plan school curricula enabling students to acquire knowledge, skills and attitudes relevant to land uses that affect water quality. Activities began early in May when teachers were recruited from a consortium of six private schools and six public Washington County school districts to attend a 1 week summer workshop. This was an intensive training program with instruction provided by project staff, extension specialists, and Wisconsin Department of Natural Resources personnel. Sessions involved the study of aquatic biology, soil characteristics, Washington County resources, and a land use simulation game, "Water and Land Resource Utilization Simulation" (WALRUS). Twenty-three teachers from 14 different schools participated; all grade levels were represented along with a variety of disciplines including social studies, communications and physical sciences.

The next segment of the project took place after the training workshop. Each participating teacher developed a unit related to soil and water resources which they would teach during the fall semester. Project staff compiled soil and water learning activities developed in environmental awareness centers throughout the country. These were given to teachers for use as "raw materials" when developing units.

The units developed for elementary school students involved a variety of lessons covering many concept areas. Some lessons included the following activities. First graders discussed the importance of water after a paper bag was placed over their bubbler during a warm September day. Other students studied soil erosion and found examples near the school. Water purification was demonstrated as students poured dirty water through a container of soil. In another activity, students learned what a watershed is, which watershed their community is in and what types of land use are common upstream.

Middle school and high school students also studied soil and water resources in many different ways. A seventh grade class discovered that the cause of bank erosion on a stream adjacent to their school was students walking along the water's edge. Another middle school class studied a nearby millpond and learned about the community's restoration program. A high school communications class studied interviewing and critical listening techniques before talking with contractors about construction site erosion. In a different approach to residential development, a social studies class learned why some community members wanted to change the zoning of a residential area to prohibit apartment buildings. A role playing activity concluded the unit with a public hearing which brought out the effect of development on a small community. An upper level physics class calculated the amount of runoff from the small watershed around their school and estimated the nutrient loading rates to an adjacent stream.

As teachers prepared and taught units, valuable assistance was provided. A tour was held for teachers to become more familiar with Washington County resource problems. Teachers made contact through project staff with government agencies such as the U.S. Soil Conservation Service, the Wisconsin Department of Natural Resources and the Southeastern Wisconsin Regional Planning Commission to obtain technical information and maps of specific resource problems. Pre- and post-tests were developed for the teachers. These tests measured student gains in knowledge, skills and attitudes.

In the second year, the program was extended to include neighboring Waukesha County. Building on the work of their associates in Washington County, teachers modified existing units and developed new ones to reflect the more urban character of their county. Also during this period, participating teachers in Washington County banded together as dissemination teams to expand the involvement of schools in the county.

Units developed by teachers for elementary grades were edited and pulled together in a book called "Local Watershed Problem Studies: Elementary School Activities." This publication has been well received and distributed widely. Currently, the U.S. Environmental Protection Agency is printing additional copies. A collection of units developed for middle and high school students has recently been made available for distribution.

A second need identified and met was an educational program which demonstrated prioritizing techniques for water quality improvement practices. A presentation for use with local citizens and decision-makers was developed using existing water quality data and overlay mapping procedures to demonstrate land use and water quality relationships. The Resource Information Program (RIP) allows targeting of technical assistance and financial incentives to landowners whose land presents the most critical problems to water quality. The program was presented in Washington County and tested further in four other counties with different topographies, soils, land uses, and water quality problems.

The program currently is being used in conjunction with the Wisconsin Fund program (State of Wisconsin) for nonpoint source pollution control. This innovative effort may well serve as a model for future federal programs designed to control nonpoint source pollutants.

A third need identified and met by the project is that of evaluation research for public participation programs. Case study analysis of P.L. 92-500 programs was undertaken to devise and test an evaluative model for and to determine effectiveness of public involvement programs. Case studies selected include the Wisconsin Department of Natural Resources, the Dane County Regional Planning Commission, Southeastern Wisconsin Regional Planning Commission, and the Washington County Project. Uses of advisory committees, public meetings and a variety of techniques for participation were included in the research. Project staff used survey and interview methods to ascertain perceptions and expectations of participating citizens and staff involved in citizen participation programs. Analysis of each program included investigation of a wide array of variables which could change the effectiveness of public involvement in planning. The model developed from the research can serve as a framework for the development of future public involvement programs and as a means of monitoring the progress of ongoing efforts.

SUMMARY

The criteria of effectiveness selected for reviewing the education and information program include meeting the originally stated goals and objectives and initiating innovative programs to meet subsequently identified needs. Using these criteria, the following assessment can be made:

1. Public awareness and understanding of the problems caused by sediment in streams, and the full range of possible preventive and corrective measures for solving these problems has been increased. Public awareness among a wide variety of individuals and groups regarding the purposes, progress and significant findings of the Washington County Project has been accomplished.

Many individuals and groups in Washington County have been contacted by the extension resource agent and the project staff. Educational and informational materials have been presented. In a survey of one of these groups, 90% of the responding persons present at the meeting indicated that their understanding of water quality problems had increased, 79% indicated their understanding of nonpoint source water quality problems had increased, and 29.6% indicated their understanding of the water quality planning process had increased. The meeting surveyed was held jointly with SEWRPC and included a full discussion of nonpoint source problems, the P.L. 92-500, Section 208 planning process and the Washington County Project programs. Attendees were self-selected individuals from the community with diverse backgrounds and interests.

2. Opportunities were provided for public interaction with the Washington County Extension Resource Agent and project staff to observe the progress and results of the project and to add public comment to the process.

Presentations by the staff to the general, interested and affected, decision-maker and expert publics were carried out during the course of the project. Staff meetings with the district supervisors and representative elected and appointed officials were scheduled regularly. Groups were contacted as previously described. An innovative educational strategy was added to the original workplan with the inclusion of local teachers into the program publics. Workshops and presentations at state soil and water conservation meetings widened the potential for interaction with decision-making and expert publics.

3. Effective informational and educational materials were developed and disseminated. Brochures, pamphlets and other publications were very readable and widely distributed. Likewise, audio-visual materials generated by the project were exposed to broad use.

Further research needs in the area of public information and involvement lie in four major areas. The educational programs dealing with public educational institutions should be expanded and extended. The problems and terminology of nonpoint source pollution and abatement are still not widely understood in many areas of the state and nation. Including this kind of information in the school curriculum would serve to educate not only the teachers and the children, but also the community touched by the school system. Developing the material which will be needed by teachers is an important contribution to encouraging better opportunities for learning. A diffusion team of teachers is already in the process of widening the educational audiences. This effort should be expanded.

A second area of need is further dissemination of the Resource Information Program. As more attention is paid to nonpoint source pollution abatement and the relationship of land management practices to water quality, better ways of identifying priority areas will be needed. Given limited conservation funds and technical assistance, the wisest use must be made of existing expertise and programs. This technique offers an effective tool for sharpening local-decision making.

A third area for additional effort lies in the development of additional informational materials. Localized and readily available printed materials will be needed for the diverse areas of Wisconsin and other states to identify and localize problems in that area and relate them to appropriate local solutions. Translation of technical detail into readily understandable and usable materials for the various publics and channels for dissemination to those publics are important additional tasks.

The final area for further work is that of developing and testing evaluative critera and models for public involvement programs. As more public involvement is mandated in environmental and other programs, it becomes increasingly important to be able to predict and measure effectiveness. Criteria for evaluation should identify a wide array of program components for examination. These criteria can be used in program design and in evaluation during and at the completion of the planning process.

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